REDACTED VERSION

Weston Solutions, Inc.
5599 San Felipe, Suite 700
Houston, Texas 77056
713-985-6600 • Fax 713-985-6703
www.westonsolutions.com

05 June 2015

Mr. Michael Pheeny
US Environmental Protection Agency
Region 6
1445 Ross Avenue, Suite 1200
Dallas, Texas 75202

RE: Tronox Navajo Area Uranium Mine (NAUM) Site Assessment Work Plan and Cost Estimate
EPA Contract No.: EP-W-06-042 Task Order 0040

Submitted via email on 05 June 2015

Dear Mr. Pheeny:

Please find attached the Final Tronox NAUM Work Plan and Cost Estimate per requirements outlined in Task Order 0040 START Statement of Work for Site Assessment dated 22 April 2015. The Work Plan includes a schedule and detailed description of the technical approach for the site assessment activities as identified in the Quality Assurance Sampling Plan (QASP) developed under Technical Direction Document No. 19/Weston-042-15-004. The Cost Estimate includes subcontractor costs for each element of the SOW with breakdown of cost in accordance with the contract work breakdown structure (WBS).

The Site Assessment Work Plan is structured following the WBS and includes the following:

- Appendix A – Task Order No. 0040
- Appendix B – QASP
- Appendix C – Task Order Cost Estimate

Weston's task order cost estimate (Appendix C) for the Total Work Breakdown Structure Elements 1 through 6 is (b) (4) [redacted]. Details for the Laboratory, Drilling and Geophysical estimates are also included in Appendix C.

Please do not hesitate to contact me should you have any questions.

Very truly yours,
Weston Solutions, Inc.

(b) (6) [redacted]
Program Manager

cc: Mr. Will LaBombard (EPA)
Ms. Lisa Price (EPA)
Ms. Rena McClurg (EPA)
(b) (6) [redacted] (Weston)

9723741

SITE ASSESSMENT
TASK WORK PLAN

FOR

TRONOX NAVAJO AREA URANIUM MINES
SAN MATEO CREEK BASIN
HIGHWAYS 509 AND 605
CIBOLA AND MCKINLEY COUNTIES, NEW MEXICO

Prepared for

U.S. Environmental Protection Agency Region 6
Will LaBombard, Project Officer
1445 Ross Avenue
Dallas, Texas 75202

Contract No. EP-W-06-042
Task Order No. 0040
WESTON Work Order No. 20406.012.040.4010.01
NRC No: N/A
CERCLIS No: NMN000606847
FPN: N/A
EPA TOM: Lisa Price
START-3 PTL: Patrick Buster

Prepared by

Weston Solutions, Inc.
Cecilia Shappee P.E., Program Manager
5599 San Felipe, Suite 700
Houston, Texas 77056
(713) 985-6600

June 2015

TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

Weston Solutions, Inc. (WESTON®), the Superfund Technical Assessment and Response Team (START-3) contractor, has been tasked by the U.S. Environmental Protection Agency (EPA) Region 6 under Contract No. EP-W-06-042, Task Order (TO) Number 0040 (Appendix A) to conduct site assessment activities at the San Mateo Creek Basin site (Site) located in Cibola and McKinley Counties, New Mexico. The Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) number assigned to the Site is NMN000606847. START-3 has prepared this site-specific Task Work Plan (TWP) to describe the technical scope of work to be performed as part of the Task Order requirements.

This document represents the TWP for the site assessment activities. The purpose of this document is to summarize available background information and to propose sample locations and field procedures that meet the requirements for conducting the site assessment. As part of the TWP, a site-specific Quality Assurance Sampling Plan (QASP) and cost estimate to complete the task order, including subcontractor costs for each element of the statement of work (SOW), are included as Appendices B and C, respectively. The cost estimate provides a breakdown of the cost by task and subtask levels, in accordance with the contract work breakdown structure (WBS).

1.1 PROJECT OBJECTIVES

The purpose of this task order is to conduct a site assessment to fill data gaps and assess the environmental impacts from legacy Kerr McGee mine operations by furthering the evaluation of alluvial groundwater quality and initiating the evaluation of bedrock groundwater quality within the San Mateo Creek Basin with a focus on the attribution to the former Kerr McGee Uranium Mine operations. Specifically, the site assessment involves the installation of monitoring wells and sample collection to evaluate the presence of uranium and other naturally-occurring constituents at anthropogenic concentrations due to mining operations.

The following WBS has been established to meet the objectives of the site assessment:

- WBS 1.1 – Work Plan
- WBS 1.2 – Site-specific Plans
- WBS 1.3 – Project Management
- WBS 1.4 – Project Initiation
- WBS 2 – Field Investigation
- WBS 3 – Data Acquisition
- WBS 4 – Analytical Support and Data Validation
- WBS 5 – Project Documentation
- WBS 6 – Task Order Closeout

The technical activities associated with the above-listed WBS are based on WESTON's understanding of the site background as summarized in Section 2 and information provided in the TO. The site-specific activities for each WBS element are described in greater detail in Section 3 of this TWP. WESTON will conduct these site assessment activities in general accordance with the following documents:

- *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (EPA/540/G-89/004).
- *Guidance for Management of Investigation-Derived Waste During Site Inspections* (EPA 540/G-91/009).

Additional guidance documents are included in Task Order No. 0040 Attachment 2 - Regulations and Guidance Documents (Appendix A).

1.2 WORK PLAN FORMAT

This TWP has been organized in a format that is intended to facilitate and effectively meet the objectives of the site assessment. The TWP is organized into the following sections:

- Section 1 – Introduction
- Section 2 – Background
- Section 3 – Scope of Work
- Section 4 – Quality Assurance
- Section 5 – Project Information

All tables referred to in this document are included at the end of each respective section.

2. BACKGROUND

The San Mateo Creek Basin comprises approximately 320 square miles within the Rio San Jose drainage basin in McKinley and Cibola Counties, New Mexico. This basin is located within the Grants Mining District (GMD), which is an area of uranium mineralization occurrence approximately 100 miles long and 25 miles wide encompassing portions of McKinley, Cibola, Sandoval, and Bernalillo counties and includes the Ambrosia Lake Mining District. Main access into the Site is provided via New Mexico State Roads 605 and 509.

There are 85 legacy uranium mines with recorded production and four legacy uranium mill sites within the San Mateo Creek Basin. Twenty-two mine operations were conducted by Kerr McGee in the Ambrosia Lake area of the basin. Most of these legacy mines were operated as wet mines, where the underground workings were dewatered and the collected mine water discharged to nearby surface drainage features such as creeks and arroyos. The mine discharge water within the drainage features infiltrated into the soils and sediment and significantly re-saturated portions of the alluvium and underlying bedrock aquifers throughout the basin. Tailing liquids from the former uranium mills also seeped downward into the alluvium and underlying bedrock aquifers. These operations may have contributed to degradation of the groundwater quality within the basin.

3. SCOPE OF WORK

The SOW for the site assessment activities is broken down into specific WBS elements. The specific work that will be performed for each WBS task is discussed in this section of the TWP and is designed to meet the objectives of the site assessment, as established in Section 1. The WBS elements include the following:

- WBS 1.1 – Work Plan
- WBS 1.2 – Site-specific Plans
- WBS 1.3 – Project Management
- WBS 1.4 – Project Initiation
- WBS 2 – Field Investigation
- WBS 3 – Data Acquisition
- WBS 4 – Analytical support and Data Validation
- WBS 5 – Project Documentation
- WBS 6 – Task Order Closeout

3.1 WBS 1.1 - WORK PLAN

The activities that will be performed as part of WBS 1.1 include background research, site reconnaissance, attendance at a scoping meeting(s), preparation of a site-specific TWP, and inclusion of a site-specific Quality Assurance Sampling Plan (QASP) prepared under Contract No. EP-W-06-042, Technical Direction Document (TDD) No. 19/WESTON-042-15-004 (Appendix B).

3.1.1 Background Research

Upon receipt of the EPA TO, START-3 began planning the specific activities to be conducted as part of the site assessment. As part of this planning effort, START-3 compiled and reviewed existing site background information and conducted literature and guidance document research.

3.1.2 Scoping Meetings and Site Visits

Prior to submittal of the site-specific TWP, START-3 contacted the EPA TOM within five calendar days after receipt of the SOW to schedule a scoping meeting which was held via conference call. Items discussed during the conference call included in the following:

- The proposed scope of the project and specific investigative and analytical activities that will be required.
- Site access issues including required State of New Mexico drilling permits.
- The site assessment objectives and general response actions.

START-3 also conducted a site reconnaissance visit with the EPA TOM representatives as part of the site assessment planning phase to determine optimal monitoring well locations based on geology, terrain, and access. A drillers' bid walk was also conducted with potential drilling subcontractors in order to refine drilling bids.

3.1.3 Site-Specific Work Plan Preparation

Following the scoping meeting, START-3 initiated the following:

- Site-specific project plans to meet the objectives of the site assessment.
- Subcontractor procurement and coordination.

In performing this task, START-3 prepared this site-specific TWP. The TWP provides a project description outlining the overall technical approach of the site assessment, and it includes the corresponding personnel requirements and activity schedules.

The purpose and general contents of the QASP are defined below.

3.1.4 Quality Assurance Sampling Plan (QASP) Preparation

WESTON has prepared a site-specific QASP that presents the field activities approach including monitoring well installation, well development, well sampling, well borehole logging, well surveying, analytical approach, and investigation-derived waste (IDW) management. Quality assurance guidelines including Data Quality Objectives (DQOs) to be followed during performance of the site assessment are also discussed. The START-3 QASP was prepared under Contract No. EP-W-06-042, Technical Direction Document No. 19/WESTON-042-15-004 and presents a description of the field sampling activities and the analytical approach that will be utilized during the site assessment activities.

The QASP includes the following:

- An overview of the San Mateo Creek Basin site.
- Objectives of the site assessment activities.
- Sampling objectives, sample locations, and sampling rationale.
- A description of the monitoring well installation, well plugging, and sample collection methods.
- Specifications of the analyses to be performed on the samples.
- Data Quality Objectives (DQOs).
- Investigation-derived waste (IDW) management.

The QASP is provided as Appendix B of this TWP.

3.1.5 Cost Estimate

START-3 prepared and estimated the cost to complete the task order, including subcontractor costs, for each element of the SOW. A breakdown of the cost by task and subtask levels, in accordance with the contract WBS is included in Appendix C.

3.2 WBS 1.2 - SITE-SPECIFIC PLANS

As part of the TO, START-3 will review all existing site-specific plans and prepare, update, and/or maintain plans, as necessary, for site assessment implementation. START-3 will incorporate the plans and procedures received from any subcontractor(s) into the overall site plans. START-3 will utilize the Tronox Mine Sites QASP, April 2015, developed under Contract No. EP-W-06-042, Technical Direction Document No. 19/WESTON-042-15-004.

3.2.1 Health and Safety Plan (HASP) Preparation

START-3 will develop a site-specific HASP and supporting radiation awareness training documents for activities associated with this site assessment. The purpose of the HASP is to protect personnel involved in site assessment activities and local residents from exposure to hazards associated with the investigation. The HASP will address applicable regulatory requirements contained in the following:

- 40 CFR 1910.120(i)(2) - Occupational Health and Safety Administration (OSHA), Hazardous Waste Operations and Emergency Response Standard, Interim Rule, December 19, 1986.
- EPA Order 1440.02 - Health and Safety Requirements for Employees Engaged in Field Activities.
- EPA Order 1440.3 - Respiratory Protection.
- EPA Occupational Health and Safety Manual.
- EPA Interim Standard Operating Procedures (September 1982).

The HASP includes general site background information and conditions and specifies the personnel responsibilities, radiation awareness, protective equipment, health and safety procedures and protocols, decontamination procedures, training, and the type and extent of medical surveillance necessary for protection from site conditions. The HASP identifies potential problems and hazards that may be encountered and explains how these will be addressed. Procedures for protecting third parties such as visitors and the surrounding community have also been provided.

The HASP will be provided as a separate deliverable following the approval of the TWP and supporting QASP documents.

3.3 WBS 1.3 - PROJECT MANAGEMENT

The objectives of Project Management and Quality Assurance is to maintain the project at a properly managed level to ensure that the quality of the work performed meets the goals and objectives set forth by the EPA, and to ensure that the EPA TOM is informed of the progress of the project. START-3 will manage the project and perform QA on all activities throughout the duration of the project. Meetings, conference calls, and progress reports will be completed to keep EPA Region 6 personnel informed of project activities.

START-3 will perform the following activities to effectively manage the task order. These activities typically include, but are not limited to, the following:

- Monitoring costs and progress by task order WBS.
- Preparing and submitting monthly progress reports that document monthly and cumulative cost by task order WBS, performance status, and technical progress.
- Preparing and submitting monthly invoices identifying expenditures by task order WBS.
- Managing, tracking, and reporting status of site-specific equipment.
- Accommodating any external audit or review mechanism that EPA requires.
- Evaluating existing data, including usability, when directed by EPA.
- Coordinating with local and emergency response teams.
- Reviewing background documents as directed by EPA.

Any confidential business information or other confidential or privileged content provided as part of the work plan and monthly reports must be placed in a separated document (addendum or attachment) clearly marked “Confidential” and attached to a publicly releasable document.

3.4 WBS 1.4 - PROJECT INITIATION

START-3 will perform project initiation and support that will lead to the design of a remedy that eliminates, reduces, or controls risks to human health and the environment. Typical activities include, but are not limited to, procuring, managing, and providing oversight of subcontractors for support services. Following development of the technical scope of work in the QASP, approach, and schedule, subcontract procurement activities were initiated. A subcontractor will be required for monitor well installation, soil boring advancement, and well geophysical surveys. In addition, a subcontracted laboratory will be used where appropriate for the analytical services required outside of the EPA Contract Laboratory Program (CLP) for the soil and groundwater samples collected during the site assessment.

3.5 WBS 2 - FIELD INVESTIGATION

The objectives of the site assessment are to fill data gaps and assess the environmental impacts from legacy Kerr McGee mine operations by furthering the evaluation of alluvial groundwater quality and initiating the evaluation of bedrock groundwater quality within the San Mateo Creek Basin with a focus on the attribution to the former Kerr McGee Uranium Mine operations. Site assessment activities involve the installation of monitoring wells and sample collection to evaluate the presence of uranium and other naturally-occurring constituents at anthropogenic concentrations due to mining operations. Specific field investigation activities are included in the Tronox Mine Sites QASP, April 2015, developed under Contract No. EP-W-06-042, Technical Direction Document No. 19/WESTON-042-15-004. Specific activities include, but are not limited to:

- Mobilization/demobilization;
- Hydrogeological assessment;
- Installation and development of new groundwater monitoring wells;
- Well logging (gamma, duel resistivity, single-point resistivity, caliper, and video) of new bedrock groundwater monitoring wells;
- Boring and/or monitoring wells logs;
- Location survey of new groundwater monitoring wells; and
- Collection of groundwater elevation measurements.

3.6 WBS 3 - DATA ACQUISITION

Data acquisition, including data quality objectives, is based on the QASP for Tronox Mine Sites, April 2015, developed under Contract No. EP-W-06-042, Technical Direction Document No. 19/WESTON-042-15-004. Typical activities include, but are not limited to:

- Sampling of existing groundwater monitoring wells;
- Sampling of newly installed groundwater monitoring wells upon installation completion; and
- Sampling of soil if no groundwater is encountered during drilling operations.

Information from the field investigation will be summarized and included in the site assessment report. START-3 will also prepare and submit to EPA Region 6 personnel weekly progress reports of the field investigation activities. The progress report will include, but is not limited to, the following:

- An outline of the field work completion schedule.

- Documentation of field activities including a copy of field logbooks and an outline of deviations from the approved project plans.
- Digital photographs of the site assessment field activities for inclusion in daily reports.
- Summary of sample field radiation survey results and general water chemistry measurements collected during well development and sampling.
- List of personnel involved in the field activities.

3.7 WBS 4 - ANALYTICAL SUPPORT AND DATA VALIDATION

The objective of this WBS element is to quantitatively analyze the samples collected during the site assessment activities and to validate the results generated by the analytical laboratories. A variety of mechanisms may be used to implement this subtask including: field screening using mobile facilities or field portable equipment, the Contract Laboratory Program (CLP), laboratories procured under subpool or team subcontracts, the Region 6 Houston Laboratory, the Environmental Response Team (ERT) laboratory, or regionally procured laboratories. For estimating purposes, the groundwater and soil/sediment samples will be analyzed through the EPA Houston Laboratory or through the CLP, and the investigation derived waste (consisting of soil cuttings and the development water) from the well installation will be analyzed through a non-EPA laboratory to facilitate disposal. Schedule, coordinate, track, and oversee sample analyses and validate analytical data based on the QASP for Tronox Mine Sites, April 2015, developed under Contract No. EP-W-06-042, Technical Direction Document No. 19/WESTON-042-15-004.

Typical activities include, but are not limited to the following:

- Collecting, preparing, and shipping environmental samples including investigation-derived waste characterization and disposal in accordance with local, state, and federal regulations.
- Requesting, obtaining, and performing oversight of analytical services in compliance with EPA requirements.
- Coordinating with the EPA Sample Management Office (SMO) and/or the Regional Sample Control Coordinator (RSCC) regarding analytical support, data validation, and quality assurance issues.

- Implementing the EPA-approved laboratory quality assurance program that provides oversight of in-house and subcontracted laboratories through periodic performance evaluation sample analyses and/or on-site audits of operations including a system of corrective actions if necessary.
- Providing sample management including chain-of-custody procedures, information management, sample retention, and 10-year data storage.
- SCRIBE will be utilized for data management and sample management and tracking procedures.

If samples are sent through the EPA RSCC, then EPA Region 6 personnel will perform validation of the CLP data obtained from the CLP or Region 6 laboratories. START-3 personnel will validate all non-CLP data according to the following guidelines:

- *EPA National Functional Guidelines for Superfund Organic Methods Data Review, OSWER 9355.0-132 EPA 540-R-014-002 August 2014*
- *EPA National Functional Guidelines for Inorganic Superfund Data Review OSWER 9355.0-131 EPA 540-R-013-001August 2014*.

Data will be validated at the required field or laboratory Quality Control (QC) level to determine whether it is appropriate for its intended use. START-3 will incorporate all sample results and validation comments into the assessment report.

3.8 WBS 5 - PROJECT DOCUMENTATION

START-3 will prepare and submit a draft site assessment report to the EPA TOM for review and comment. Once comments on the draft assessment are received, START-3 will prepare a final assessment report reflecting these comments. Specific activities include compiling analytical and field data and providing data in a format that is compatible with Regional or National electronic data management network. Typical activities include, but are not limited to, the following:

- Data usability evaluation and field quality assurance/quality control
- Separate information collections including:
  - Soil boring and monitoring well construction logs
  - Geophysical data from newly installed bedrock monitoring wells

- Analytical results (in a searchable electronic format such as SCRIBE)

3.9 WBS 6 - TASK ORDER CLOSEOUT

START-3 will conduct TO closeout activities in accordance with contract and TO requirements. Typical activities include, but are not limited to, the following:

- Packaging and returning documents to the government.
- Duplicating/distribution/storage of files.
- Archiving files in accordance with Federal Record Center requirements.
- Preparing microfiche/microfilm/optical disk or other EPA-approved data storage technology.
- Preparing the closeout report in accordance with regional guidance or other procedures as specified in the TO. If the final hours/budget is greater than +/- 10% of the original approved work plan/task order hours/budget, the Task Order Contractor's Representative (TOCR) must describe the circumstances that explain why this occurred.

4. QUALITY ASSURANCE

Quality Assurance (QA) will be conducted in accordance with EPA's quality management requirements (*EPA Requirements for Quality Assurance Project Plans (QA/R-5*) [EPA/240/B-01/003, dated March 2001]; and *EPA Guidance for Quality Assurance Project Plans* [EPA/240/R-02/009, dated December 2002]). Standard Operating Procedures (SOPs) for field sampling, analytical screening methods, and other field activities will be conducted following EPA ERT Standard Operating Procedures (various dates), as applicable.

A Quality Assurance (QA) officer will be assigned and will monitor work conducted throughout the entire project including reviewing interim report deliverables and field audits. The PTL will be responsible for QA/QC of the field investigation activities. The designated laboratory utilized during the investigation will be responsible for QA/QC related to the analytical work. The Project Chemist will verify that laboratory QA/QC is consistent with the required standards and provide data validation support once the laboratory data has been received.

5. PROJECT INFORMATION

This section outlines basic project management information for the site assessment activities. Details concerning key personnel and the project schedule are provided.

5.1 KEY PROJECT PERSONNEL

START-3 project personnel dedicated and supporting this project are shown on Table 5-1. The key project personnel are shown on Figure 5-1.

5.2 PROJECT SCHEDULE

The overall project schedule is summarized in Table 5-2.

Figure 5-1
Key Project Personnel

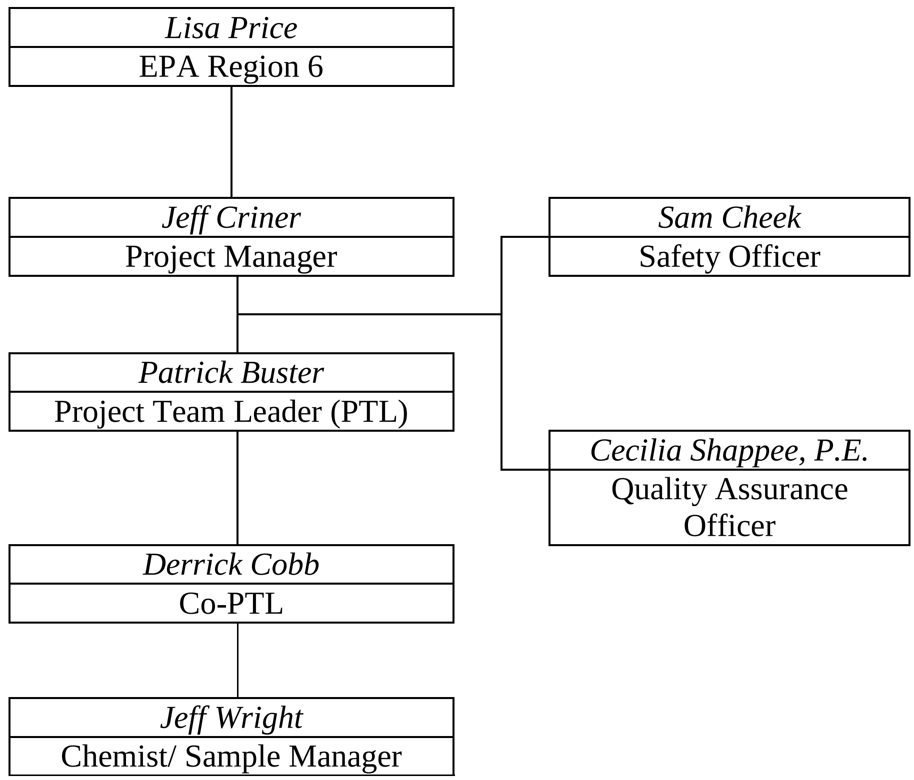


Table 5-1
Anticipated Project Personnel

Name	Title	Roles	Project Responsibilities
Jeff Criner	Project Manager	Project Manager	Overall implementation of site assessment work plan, QASP, and HASP. Staff Scheduling. EPA Liaison.
Derrick Cobb	Senior Geoscientist	Co-Team Leader Field Safety Officer	Implementation of QASP in the field. Supervision of drilling activities. Well Geophysics. Collection of Samples. Project Field Coordinator.
Sam Cheek	Safety Officer	Regional Safety Officer	Implementation of HASP.
Patrick Buster	Geoscientist	Co-Team Leader Field Safety Officer	Implementation of QASP in the field. Collection of Samples. Project Field Coordinator. Radiation monitoring/monitoring equipment calibration. Collection of samples. Supervision of drilling activities. Equipment management and decontamination. Mobilization/Demobilization.
Bob Schoenfelder	Health Physicist	Regional Radiation Safety Officer	Radiation awareness training, HP support and guidance during and after field activities.
Jeff Wright	Chemist	Regional Chemist	Laboratory procurement and support. Sample management support.

Notes:
Additional field samplers and data management personnel may assist on this project.

Table 5-2
Project Schedule (1 May 2015 – 1 June 2016)

WBS Target Milestones	MAY '15	JUN '15	JUL '15	AUG '15	SEP '15	OCT '15	NOV '15	DEC '15	JAN '16	FEB '16	MAR '16	APR '16	MAY '16	JUN '16
WBS 1.1 – Prepare and submit a Tronox NAUM Site Assessment Work Plan														
WBS 1.2 – SITE SPECIFIC PLANS - Review, update and/or maintain current submitted plans and prepare a site-specific Health and Safety Plan.														
WBS 1.3 – PROJECT MANAGEMENT - Monitor costs and project progress. Prepare and submit monthly WBS progress and technical reports and monthly invoices.														
WBS 1.4 – PROJECT INITIATION - Procuring, managing, and providing oversight of pool and team subcontractors.														
WBS 2 – FIELD INVESTIGATION - Mobilization and demobilization for the hydrogeological assessment. Including installation and development of groundwater monitor wells, completion of boring and/or monitor well logs, survey of newly installed wells, and collection of elevation measurements.														
WBS 3 – DATA ACQUISITION - including the sampling of newly installed and previously existing monitor wells and soil/sediment sampling when groundwater is not encountered.														
WBS 4 – ANALYTICAL SUPPORT AND DATA VALIDATION - Collection and submission of environmental samples along with requesting and obtaining analytical services. Coordinating with the EPA SMO and/or the RSCC.														
WBS 5 – PROJECT DOCUMENTATION - including data usability evaluations and field QA/QC, boring/well logs, geophysical data, and analytical results.														
WBS 6 – TASK ORDER CLOSEOUT														

APPENDIX A

TASK ORDER NO. 0040

ORDER FOR SUPPLIES OR SERVICES

IMPORTANT: Mark all packages and papers with contract and/or order numbers.

1. DATE OF ORDER: 05/01/2015
2. CONTRACT NO. (If any): EP-W-06-042
3. ORDER NO.: 0040
4. REQUISITION/REFERENCE NO.: PR-R6-15-00167
5. ISSUING OFFICE (Address correspondence to):
Region 6
US Environmental Protection Agency
1445 Ross Avenue
Suite 1200
Dallas TX 75202-2733

6. SHIP TO:
a. NAME OF CONSIGNEE: Region 6
b. STREET ADDRESS: US Environmental Protection Agency, 1445 Ross Avenue, Suite 1200
c. CITY: Dallas
d. STATE: TX
e. ZIP CODE: 75202-2733
f. SHIP VIA

7. TO: NA
a. NAME OF CONTRACTOR: WESTON SOLUTIONS, INC
b. COMPANY NAME
c. STREET ADDRESS: 1400 WESTON WAY
ATTN: [redacted]
d. CITY: WEST CHESTER
e. STATE: PA
f. ZIP CODE: 193801492

8. TYPE OF ORDER
☐ a. PURCHASE
REFERENCE YOUR:

Please furnish the following on the terms and conditions specified on both sides of this order and on the attached sheet, if any, including delivery as indicated.

☒ b. DELIVERY
Except for billing instructions on the reverse, this delivery order is subject to instructions contained on this side only of this form and is issued subject to the terms and conditions of the above-numbered contract.

9. ACCOUNTING AND APPROPRIATION DATA: See Schedule
10. REQUISITIONING OFFICE: R6/D/SF

11. BUSINESS CLASSIFICATION (Check appropriate box(es))
☐ a. SMALL ☒ b. OTHER THAN SMALL ☐ c. DISADVANTAGED ☐ d. WOMEN-OWNED ☐ e. HUBZone
☐ f. SERVICE-DISABLED VETERAN-OWNED ☐ g. WOMEN-OWNED SMALL BUSINESS (WOSB) ELIGIBLE UNDER THE WOSB PROGRAM ☐ h. EDWOSB

12. F.O.B. POINT: Destination

13. PLACE OF
a. INSPECTION
b. ACCEPTANCE
14. GOVERNMENT B/L NO.
15. DELIVER TO F.O.B. POINT ON OR BEFORE (Date): 1 Days After Award
16. DISCOUNT TERMS

17. SCHEDULE (See reverse for Rejections)

ITEM NO. (a)	SUPPLIES OR SERVICES (b)	QUANTITY ORDERED (c)	UNIT (d)	UNIT PRICE (e)	AMOUNT (f)	QUANTITY ACCEPTED (g)
	DUNS Number: 044519429 TOCOR: Labombard Continued ...					

18. SHIPPING POINT
19. GROSS SHIPPING WEIGHT
20. INVOICE NO.
17(h) TOTAL (Cont. pages): [redacted]

21. MAIL INVOICE TO:
SEE BILLING INSTRUCTIONS ON REVERSE
a. NAME: RTP Finance Center
b. STREET ADDRESS (or P.O. Box): US Environmental Protection Agency, RTP-Finance Center, Mail Drop D143-02, 109 TW Alexander Drive
c. CITY: Durham
d. STATE: NC
e. ZIP CODE: 27711
17(i) GRAND TOTAL: [redacted]

22. UNITED STATES OF AMERICA BY (Signature): [signature]
23. NAME (Typed): Michael J. Pheeny
TITLE: CONTRACTING/ORDERING OFFICER

ORDER FOR SUPPLIES OR SERVICES
SCHEDULE - CONTINUATION

IMPORTANT: Mark all packages and papers with contract and/or order numbers.

DATE OF ORDER	CONTRACT NO.	ORDER NO.
05/01/2015	EP-W-06-042	0040

ITEM NO. (a)	SUPPLIES/SERVICES (b)	QUANTITY ORDERED (c)	UNIT (d)	UNIT PRICE (e)	AMOUNT (f)	QUANTITY ACCEPTED (g)
	Admin Office: Region 6 US Environmental Protection Agency 1445 Ross Avenue Suite 1200 Dallas TX 75202-2733 Accounting Info: 15-TR2-06L-303DD2-2505-C001-1506LVR013-001 BFY: 15 Fund: TR2 Budget Org: 06L Program (PRC): 303DD2 Budget (BOC): 2505 Job #: A6KZQB00 Cost: C001 DCN - Line ID: 1506LVR013-001 Period of Performance: 05/01/2015 to 06/21/2016					
0001	Add [redacted] of TR2 to Weston TO 0040, Tronox Navajo Area Uranium Mines (NAUM) San Mateo Creek Basin Site Assessment. The obligated amount of award: [redacted]. The total for this award is shown in box 17(i).				[redacted]	
	TOTAL CARRIED FORWARD TO 1ST PAGE (ITEM 17(H))				[redacted]	

AUTHORIZED FOR LOCAL REPODUCTION
PREVIOUS EDITION NOT USABLE

OPTIONAL FORM 348 (Rev. 4/2006)
Prescribed by GSA FAR (48 CFR) 53.213(f)

START STATEMENT OF WORK FOR
SITE ASSESSMENT
Action Code QB
Tronox Navajo Area Uranium Mines San Mateo Creek Basin
April 22, 2015

Contract No: EP-W-06-042
Task Order No:

Introduction

PURPOSE

The purpose of this task order is to conduct a site assessment to fill data gaps and assess the environmental impacts from legacy Kerr McGee mine operations by furthering the evaluation of alluvial groundwater quality and initiating the evaluation of bedrock groundwater quality within the San Mateo Creek Basin with a focus on the attribution to the former Kerr McGee Uranium mine operations. Specifically, the site assessment involves the installation of monitoring wells and sample collection to evaluate the presence of uranium and other naturally-occurring constituents at anthropogenic concentrations due to mining operations. This statement of work (SOW) sets forth the framework and requirements for this effort. The estimated completion of this task order in June 30, 2016.

SITE DESCRIPTION

The San Mateo Creek Basin comprises approximately 320 square miles within the Rio San Jose drainage basin in McKinley and Cibola Counties, New Mexico. This basin is located within the Grants Mining District (GMD), which is an area of uranium mineralization occurrence approximately 100 miles long and 25 miles wide encompassing portions of McKinley, Cibola, Sandoval, and Bernalillo counties and includes the Ambrosia Lake Mining District. Main access into the Site is provided via New Mexico State Roads 605 and 509.

There are 85 legacy uranium mines with recorded production and four legacy uranium mill sites within the San Mateo Creek Basin. Twenty-two mine operations were conducted by Kerr McGee in the Ambrosia Lake area of the basin. Most of these legacy mines were operated as wet mines, where the underground workings were dewatered and the collected mine water discharged to nearby surface drainage features such as creeks and arroyos. The mine discharge water within the drainage features infiltrated into the soils and sediment and significantly re-saturated portions of the alluvium and underlying bedrock aquifers throughout the basin. Tailing liquids from the former uranium mills also seeped downward into the alluvium and underlying bedrock aquifers. These operations may have contributed to degradation of the groundwater quality within the basin.

GENERAL REQUIREMENTS

This is a fixed rate task order that requires the contractor to furnish all necessary and appropriate personnel, materials, and services needed for, or incidental to, performing and completing the site assessment activities in accordance with the requirements of this SOW.

In conducting the task order, EPA expects the contractor to propose and implement the most appropriate and cost-effective procedures and methodologies using accepted engineering practices and controls. Throughout the performance of this task order, EPA expects the contractor to be responsible for performing services and providing products at the lowest reasonable cost. If the contractor fails to meet the requirements within the negotiated costs, the government may elect to provide the contractor with additional funds to complete the task order without providing any additional fee. If there are changes to the SOW by the government, the government will issue a formal amendment to the SOW and negotiate the cost of the amendment with the contractor to form a new cost estimate.

A summary of the potential major deliverables and proposed schedule for submittals is in Attachment 1. This summary and schedule can be used as the basis for the contractor's proposed deliverables and schedules included in the work plan. Submit the major deliverables using the Transmittal of Documents for Acceptance by EPA Form (Attachment 3). The EPA Task Order Manager (TOM) will track deliverables submitted by the contractor using the Transmittal Register (Attachment 4).

A list of primary guidance and reference material is provided in Attachment 2. In all cases, the contractor shall use the most recently issued guidance.

Communicate at least weekly with the EPA TOM, either in face-to-face meetings or through conference calls. Document all decisions that are made in meetings and conversations with EPA via the monthly progress reports.

EPA provides oversight of contractor activities throughout the site assessment activities. EPA review and approval of deliverables is a tool to assist this process and to satisfy, in part, EPA's responsibility to provide effective protection of public health, welfare, and the environment. EPA also reviews deliverables to assess the likelihood that the completed work will achieves its goals and that its performance and operations requirements have been met. Acceptance of deliverables by EPA does not relieve the contractor from responsibility for the adequacy of the deliverables or its professional responsibilities.

RECORD KEEPING REQUIREMENTS

Maintain all technical and financial records for the site assessment activities in accordance with the contract. At the completion of the task order, submit an official record of the site assessment activities in both compact disk and a hardcopy to the TOM. Provide the deliverables using electronic media.

USEPA PRIMARY CONTACTS

The primary contact for this task order is Lisa Price. She can be reached at (214) 665-6744, via facsimile at (214) 665-6660, or via e-mail at price.lisa@epa.gov. Her mailing address is US EPA Region 6, Superfund Division (6SF-TR), 1445 Ross Avenue, Dallas, TX 75202-2733.

TASK ORDER COMPLETION DATE AND PROJECT CLOSEOUT

At the completion of the task order, perform all necessary project closeout activities as specified in the contract. These activities include closing out any subcontracts, indexing and consolidating project records and files as required above, and providing a technical and financial closeout report to EPA. The goal is to complete all technical activities and closeout activities for this task order by June 1, 2016.

WORK PLAN WBS 1.1

Prepare and submit a Tronox Navajo Area Uranium Mine (NAUM) Site Assessment Work Plan that includes a detailed description and cost breakdown for the field activities specified in the Quality Assurance Sampling Plan (QASP) for Tronox Mine Sites, April 2015, developed under Contract No. EP-W-06-042, Technical Direction Document No. 19/WESTON-042-15-004. Typical activities involved in preparing the work plan include, but are not limited to, the following:

- Attend Scoping Meeting: Contact the Task Order Manager (TOM) within five calendar days after receipt of the SOW from EPA to schedule the scoping meeting to be held at the U.S. EPA Region 6 office in Dallas, TX, or by conference call.
- Conduct Site Visit: Conduct site visit with the TOM or TOM representative(s) during the site assessment planning phase to determine optimal monitoring well locations based on geology, terrain and access. Potential drilling subcontractors should be invited to the site visit in order to refine drilling bids.

- Develop Work Plan: Prepare and submit a final Tronox NAUM Site Assessment Work Plan within 30 calendar days after receipt of the SOW from EPA. The work plan shall include a schedule and detailed description of the technical approach for the site assessment activities as identified in the QASP for Tronox Mine Sites, April 2015, developed under Contract No. EP-W-06-042, Technical Direction Document No. 19/WESTON-042-15-004. Activities include assistance with access to properties and obtaining drilling permits.
- Cost Estimate: Prepare and estimate cost to complete the task order, including subcontractor costs, for each element of the SOW; providing a breakdown of the cost by task and subtask levels, in accordance with the contract work breakdown structure (WBS).

SITE-SPECIFIC PLANS WBS: 1.2

Review all existing site-specific plans and prepare, update, and/or maintain plans, as necessary, for site assessment implementation. Incorporate the plans and procedures received from any subcontractor(s) into the overall site plans. Should the contractor fail to meet the required standards in accordance with the appropriate legal, regulatory, and EPA guidance, prepare revised site-specific plans. Typical plans include, but are not limited to, the following:

- QASP for Tronox Mine Sites, April 2015, developed under Contract No. EP-W-06-042, Technical Direction Document No. 19/WESTON-042-15-004.
- Site-specific Health and Safety Plan (HSP) that specifies employee training, protective equipment, medical surveillance requirements, standard operating procedures, and a contingency plan in accordance with 29 CFR 1910.120(l)(1) and (l)(2).

PROJECT MANAGEMENT WBS 1.3

Perform activities required to effectively manage the task order. These activities typically include, but are not limited to, the following:

- Monitoring costs and progress by task order WBS
- Preparing and submitting monthly progress reports that document monthly and cumulative cost by task order WBS, performance status, and technical progress
- Preparing and submitting monthly invoices identifying expenditures by task order WBS
- Managing, tracking, and reporting status of site-specific equipment
- Accommodating any external audit or review mechanism that EPA requires
- Evaluating existing data, including usability, when directed by EPA
- Coordinating with local and emergency response teams
- Reviewing background documents as directed by EPA

Any confidential business information or other confidential or privileged content provided as part of the work plan and monthly reports must be placed in a separated document (addendum or attachment) clearly marked "Confidential" and attached to a publicly releasable document.

PROJECT INITIATION WBS: 1.4

Perform project initiation and support that will lead to the design of a remedy that eliminates, reduces, or controls risks to human health and the environment. Typical activities include, but are not limited to, the following

- Procuring, managing, and providing oversight of pool and team subcontracts for support services.

FIELD INVESTIGATION WBS 2

Collect environmental data required to fill data gaps and assess the environmental impacts from legacy Kerr McGee mine operations by furthering the evaluation of alluvial groundwater quality and initiating the evaluation of bedrock groundwater quality within the San Mateo Creek Basin with a focus on the attribution to the former Kerr McGee Uranium mine operations. Data acquisition, including data quality objectives, is based on the QASP for Tronox Mine Sites, April 2015, developed under Contract No. EP-W-06-042, Technical Direction Document No. 19/WESTON-042-15-004. Typical activities include, but are not limited to:

- Mobilization/demobilization
- Hydrogeological assessment
- Installation and development of new groundwater monitoring wells
- Well logging (gamma, duel resistivity, single point resistivity, caliper, and video) of new bedrock groundwater monitoring wells
- Boring and/or monitoring wells logs
- Location survey of new groundwater monitoring wells
- Collect groundwater elevation measurements

DATA ACQUSITION WBS 3

Data acquisition, including data quality objectives, is based on the QASP for Tronox Mine Sites, April 2015, developed under Contract No. EP-W-06-042, Technical Direction Document No. 19/WESTON-042-15-004. Typical activities include, but are not limited to:

- sampling groundwater wells
    - new groundwater monitoring wells upon installation completion
    - existing groundwater wells
- soil/sediment sampling of the in the event no groundwater is encountered during drilling

ANALYTICAL SUPPORT AND DATA VALIDATION WBS 4

A variety of mechanisms may be used to implement this subtask including: field screening using mobile facilities or field portable equipment, the Contract Laboratory Program (CLP), laboratories procured under subpool or team subcontracts, the Region 6 Houston Laboratory, the Environmental Response Team (ERT) laboratory, or regionally procured laboratories. For estimating purposes, the groundwater and soil/sediment samples will be analyzed through the EPA Houston Laboratory or through the CLP; and, the investigation derived waste (consisting of soil cuttings and the development water) from the well installation will be analyzed through a non-EPA lab to facilitate disposal. Schedule, coordinate, track, and oversee sample analyses and validate analytical data based on the QASP for Tronox Mine Sites, April 2015, developed under Contract No. EP-W-06-042, Technical Direction Document No. 19/WESTON-042-15-004. Typical activities include, but are not limited to:

- Collecting, preparing, and shipping environmental samples including investigation-derived waste characterization and disposal in accordance with local, state and federal regulations
- Requesting, obtaining, and performing oversight of analytical services in compliance with EPA requirements
- Coordinating with the EPA Sample Management Office (SMO), and/or the Regional Sample Control Coordinator (RSCC) regarding analytical support, data validation, and quality assurance issues
- Implementing the EPA-approved laboratory quality assurance program that provides oversight of in-house and subcontracted laboratories through periodic performance evaluation sample analyses and/or on-site audits of operations and has a system of corrective actions
- Providing sample management including chain of custody procedures, information management, sample retention, and 10-year data storage

PROJECT DOCUMENTATION WBS 5

Compile analytical and field data. Provide data in format that is compatible with Regional or National electronic data management network. Typical activities include, but are not limited to, the following:

- Data usability evaluation and field quality assurance/quality control
- Separate information collections:
    - soil boring and monitoring well logs
    - geophysical data
    - analytical results (in a searchable electronic format)

TASK ORDER CLOSEOUT WBS 6

Perform the necessary activities to close out the task order in accordance with contract requirements. Typical activities include, but are not limited to, the following:

- Packaging and returning documents to the government
- Duplicating/distribution/storage of files
- Archiving files in accordance with Federal Record Center requirements
- Preparing microfiche/microfilm/optical disk or other EPA-approved data storage technology
- Preparing the closeout report in accordance with Regional guidance or other procedures as specified in the task order. If the final hours/budget is greater than +/- 10% of the original approved work plan/task order hours/budget, the TOCR must describe the circumstances that explain why this occurred

Attachment 1 - Summary of Major Submittals for the Site Assessment for the Tronox NAUM in the San Mateo Creek Basin

DELIVERABLE	NO. OF COPIES	DUE DATE	EPA REVIEW PERIOD
Site Assessment Tronox NAUM Work Plan	2 hard copies (HC) 1 electronic copy (EC)	Within 30 days after receipt of the SOW from EPA	5 days after receipt of work plan
Health and Safety Plan (HASP)	2 HC and 2 EC	21 days after approval of the work plan	14 days after receipt of plan
Monthly Progress Reports	1 HC and 1 EC	Monthly and as required in the contract	N/A
Field Reports	1 EC	Friday of every week of field activities (covering activities through noon on Thursday)	3 days after receipt
Monitoring Well Logs	2 HC and 2 EC	10 days after well completion	21 days after receipt
Data Validation Report	1 HC and 1EC	7 days after receipt of all analytical results from laboratory	14 days after receipt
Project Documentation Report	1 HC and 1 EC	21 days after receipt of all analytical results from laboratory	14 days after receipt
Closeout Report	1 HC and 1EC	As directed in the Task Order Closeout Notification	21 days after receipt of report
Final Costs	1 HC and 1EC	90 days after Task Order Closeout	

Attachment 2 - Regulations and Guidance Documents

The following list, although not comprehensive, consists of many of the regulations and guidance documents that apply to the RI/FS process:

1. American National Standards Practices for Respiratory Protection. American National Standards Institute Z88.2-1980, March 11, 1981.
2. ARCS Construction Contract Modification Procedures, September 1989, OERR Directive 9355.5-01/FS.
3. CERCLA Compliance with Other Laws Manual, Two Volumes, U.S. EPA, Office of Emergency and Remedial Response, August 1988 (DRAFT), OSWER Directive No. 9234.1-01 and -02.
4. Community Relations in Superfund - A Handbook, U.S. EPA, Office of Emergency and Remedial Response, January 1992, OSWER Directive No. 9230.0-3C.
5. A Compendium of Superfund Field Operations Methods, Two Volumes, U.S. EPA, Office of Emergency and Remedial Response, EPA/540/P-87/001a, August 1987, OSWER Directive No. 9355.0-14.
6. Construction Quality Assurance for Hazardous Waste Land Disposal Facilities, U.S. EPA, Office of Solid Waste and Emergency Response, October 1986, OSWER Directive No. 9472.003.
7. Contractor Requirements for the Control and Security of RCRA Confidential Business Information, March 1984.
8. Data Quality Objectives for Remedial Response Activities, U.S. EPA, Office of Emergency and Remedial Response and Office of Waste Programs Enforcement, EPA/540/G-87/003, March 1987, OSWER Directive No. 9335.0-7B.
9. Engineering Support Branch Standard Operating Procedures and Quality Assurance Manual, U.S. EPA Region IV, Environmental Services Division, April 1, 1986 (revised periodically).
10. EPA NEIC Policies and Procedures Manual, EPA-330/9-78-001-R, May 1978, revised November 1984.
11. Federal Acquisition Regulation, Washington, DC: U.S. Government Printing Office (revised periodically).
12. Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, Interim Final, U.S. EPA, Office of Emergency and Remedial Response, October 1988, OSWER Directive NO. 9355.3-01.
13. Guidance on EPA Oversight of Remedial Designs and Remedial Actions Performed by Potential Responsible Parties, U.S. EPA Office of Emergency and Remedial Response, EPA/540/G-90/001, April 1990.
14. Guidance on Expediting Remedial Design and Remedial Actions, EPA/540/G-90/006, August 1990.
15. Guidance on Remedial Actions for Contaminated Ground Water at Superfund Sites, U.S. EPA Office of Emergency and Remedial Response (DRAFT), OSWER Directive No. 9283.1-2.
16. Guide for Conducting Treatability Studies Under CERCLA, U.S. EPA, Office of Emergency and Remedial Response, Prepublication version.
17. Guide to Management of Investigation-Derived Wastes, U.S. EPA, Office of Solid Waste and Emergency Response, Publication 9345.3-03FS, January 1992.
18. Guidelines and Specifications for Preparing Quality Assurance Project Plans, U.S. EPA, Office of Research and Development, Cincinnati, OH, QAMS-004/80, December 29, 1980.
19. Health and Safety Requirements of Employees Employed in Field Activities, U.S. EPA, Office of Emergency and Remedial Response, July 12, 1982, EPA Order No. 1440.2.
20. Interim Guidance on Compliance with Applicable of Relevant and Appropriate Requirements, U.S. EPA, Office of Emergency and Remedial Response, July 9, 1987, OSWER Directive No. 9234.0-05.
21. Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans, U.S. EPA, Office of Emergency and Remedial Response, QAMS-005/80, December 1980.
22. Methods for Evaluating the Attainment of Cleanup Standards: Vol. 1, Soils and Solid Media, February 1989, EPA 23/02-89-042; vol. 2, Ground Water (Jul 1992).
23. National Oil and Hazardous Substances Pollution Contingency Plan; Final Rule, Federal Register 40 CFR Part 300, March 8, 1990.
24. NIOSH Manual of Analytical Methods, 2nd edition. Volumes I-VII for the 3rd edition, Volumes I and II, National Institute of Occupational Safety and Health.
25. Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities, National Institute of Occupational Safety and Health/Occupational Health and Safety Administration/United States Coast Guard/Environmental Protection Agency, October 1985.
26. Permits and Permit Equivalency Processes for CERCLA On-Site Response Actions, February 19, 1992, OSWER Directive 9355.7-03.
27. Procedure for Planning and Implementing Off-Site Response Actions, Federal Register, Volume 50, Number 214, November 1985, pages 45933-45937.
28. Procedures for Completion and Deletion of NPL Sites, U.S. EPA, Office of Emergency and Remedial Response, April 1989, OSWER Directive No. 9320.2-3A.

29. Quality in the Constructed Project: A Guideline for Owners, Designers and Constructors, Volume 1, Preliminary Edition for Trial Use and Comment, American Society of Civil Engineers, May 1988.
30. Remedial Design and Remedial Action Handbook, U.S. EPA, Office of Emergency and Remedial Response, June 1995, OSWER Directive No. 9355.5-22.
31. Revision of Policy Regarding Superfund Project Assignments, OSWER Directive No. 9242.3-08, December 10, 1991. [Guidance, p. 2-2]
32. Scoping the Remedial Design (Fact Sheet), February 1995, OSWER Publ. 9355-5-21 FS.
33. Standard Operating Safety Guides, U.S. EPA, Office of Emergency and Remedial Response, November 1984.
34. Standards for the Construction Industry, Code of Federal Regulations, Title 29, Part 1926, Occupational Health and Safety Administration.
35. Standards for General Industry, Code of Federal Regulations, Title 29, Part 1910, Occupational Health and Safety Administration.
36. Structure and Components of 5-Year Reviews, OSWER Directive No. 9355.7-02, May 23, 1991. [Guidance, p. 3-5]
37. Superfund Guidance on EPA Oversight of Remedial Designs and Remedial Actions Performed by Potentially Responsible Parties, April 1990, EPA/540/G-90/001.
38. Superfund Remedial Design and Remedial Action Guidance, U.S. EPA, Office of Emergency and Remedial Response, June 1986, OSWER Directive No. 9355.0-4A.
39. Superfund Response Action Contracts (Fact Sheet), May 1993, OSWER Publ. 9242.2-08FS.
40. TLVs-Threshold Limit Values and Biological Exposure Indices for 1987-88, American Conference of Governmental Industrial Hygienists.
41. Treatability Studies Under CERCLA, Final. U.S. EPA, Office of Solid Waste and Emergency Response, EPA/540/R-92/071a, October 1992.
42. USEPA Contract Laboratory Program Statement of Work for Inorganic Analysis, U.S. EPA, Office of Emergency and Remedial Response, July 1988.
43. USEPA Contract Laboratory Program Statement of Work for Organic Analysis, U.S. EPA, Office of Emergency and Remedial Response, February 1988.
44. User's Guide to the EPA Contract Laboratory Program, U.S. EPA, Sample Management Office, August 1982.
45. Value Engineering (Fact Sheet), U.S. EPA, Office of Solid Waste and Emergency Response, Publication 9355.5-03FS, May 1990.

See the following guidance documents for more information on performance-based contracting:

46. A Guide to Best Practices for Performance-Based Service Contracting, Office of Federal Procurement Policy, April 1996.
47. A Guide to Best Practices for Performance-Based Service Contracting, Final Edition, Office of Federal Procurement Policy, October 1998.
48. Performance-Based Contracting (Fact Sheet), U.S. EPA, Office of Emergency and Remedial Response, Draft February 1999.
49. Policy Letter 91-2, To The Heads of Executive Agencies and Departments, April 9, 1991.

Attachment 3 - Transmittal Of Documents For Acceptance By EPA

<table>
<tr><td colspan="3">TRANSMITTAL OF DOCUMENTS FOR ACCEPTANCE BY EPA</td><td>DATE:</td><td>TRANSMITTAL NO.</td></tr>
<tr><td colspan="2">TO:</td><td colspan="2">FROM:</td><td>G New Transmittal
G Re-submittal of Transmittal No. ________</td></tr>
<tr><td>SUBTASK NO.</td><td colspan="2">DELIVERABLE</td><td>NO. OF COPIES</td><td>REMARKS</td></tr>
<tr><td></td><td colspan="2"></td><td></td><td></td></tr>
<tr><td></td><td colspan="2"></td><td></td><td></td></tr>
<tr><td></td><td colspan="2"></td><td></td><td></td></tr>
<tr><td></td><td colspan="2"></td><td></td><td></td></tr>
<tr><td></td><td colspan="2"></td><td></td><td></td></tr>
<tr><td></td><td colspan="2"></td><td></td><td></td></tr>
<tr><td></td><td colspan="2"></td><td></td><td></td></tr>
<tr><td></td><td colspan="2"></td><td></td><td></td></tr>
<tr><td></td><td colspan="2"></td><td></td><td></td></tr>
<tr><td></td><td colspan="2"></td><td></td><td></td></tr>
<tr><td></td><td colspan="2"></td><td></td><td></td></tr>
<tr><td></td><td colspan="2"></td><td></td><td></td></tr>
<tr><td colspan="5">ACCEPTANCE ACTION</td></tr>
<tr><td colspan="2">DOCUMENTS FOUND ACCEPTABLE (LIST BY SUBTASK NO.)</td><td colspan="3">NAME/TITLE/SIGNATURE OF REVIEWER
DATE</td></tr>
</table>

Attachment 4 - Transmittal Register

TRANSMITTAL REGISTER								
PROJECT TITLE AND LOCATION				CONTRACT NO.			WORK ASSIGNMENT NO.	
Subtask No.	DELIVERABLE	No. of Copies	Due Date	Transmittal No.	Date Received	Date Comments Sent to Contractor	EPA Acceptance Date	REMARKS

APPENDIX B

QUALITY ASSURANCE SAMPLING PLAN (QASP) PREPARED UNDER CONTRACT NO. EP-W-06-042, TECHNICAL DIRECTION DOCUMENT (TDD) NO. 19/WESTON-042-15-004

QUALITY ASSURANCE SAMPLING PLAN

FOR

TRONOX MINE SITES R6/R9
HIGHWAYS 509 AND 605
CIBOLA AND MCKINLEY COUNTIES, NEW MEXICO

Prepared for

U.S. Environmental Protection Agency Region 6
Will LaBombard, Project Officer
1445 Ross Avenue
Dallas, Texas 75202

Contract No. EP-W-06-042
Technical Direction Document No. 19/WESTON-042-15-004
WESTON Work Order No. 20406.012.019.0930.01
NRC No: N/A
CERCLIS No: NMN000606847
FPN: N/A
EPA TOM: Lisa Price
START-3 PTL: Patrick Buster

Prepared by

Weston Solutions, Inc.
Cecilia Shappee P.E., Program Manager
5599 San Felipe, Suite 700
Houston, Texas 77056
(713) 985-6600

April 2015

TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINTUED)

Section **Page**

LIST OF APPENDICES

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

Weston Solutions, Inc. (WESTON®), the Superfund Technical Assessment and Response Team (START-3) contractor (EPA Team), has been tasked by U.S. Environmental Protection Agency (EPA) Region 6 Prevention and Response Branch (PRB) under Contract Number EP-W-06-042 and Technical Direction Document (TDD) No. 19/WESTON-042-15-004 (Appendix E), to conduct a groundwater investigation at the San Mateo Creek Basin site (Site) located in Cibola and McKinley Counties, New Mexico. The Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) number assigned to the Site is NMN000606847. The EPA Team has prepared this Quality Assurance Sampling Plan (QASP) to describe the field investigation activities including monitoring well drilling and installation, groundwater sampling, investigation-derived waste management (IDW) plan, well geophysical logging, surveying, and analytical scope of work to be completed as part of the TDD requirements.

1.1 PROJECT OBJECTIVES

The EPA Team is providing technical assistance to EPA Region 6 for performance of this additional phase of the groundwater investigation. The objective of the investigation is to fill data gaps and assess the environmental impacts from legacy Kerr McGee mine operations by furthering the evaluation of alluvial groundwater quality and initiating the evaluation of Dakota Sandstone and San Andres-Glorieta (SAG) limestone groundwater quality within the San Mateo Creek Basin with a focus on the attribution to the former Kerr McGee Uranium Mine operations.

The objective of the investigation will be achieved by evaluating data obtained during the field investigation through collection and analysis of groundwater from newly installed monitoring wells and groundwater samples from existing monitoring wells located in the San Mateo Creek Basin.

1.2 PROJECT TEAM

The EPA Team will consist of Jeff Criner, the EPA Team Assessment/Inspection Manager; Patrick Buster, the EPA Team Project Team Leader (PTL); Cecilia Shappee, P.E., the Quality Assurance Officer; Jeff Wright, CHMM, Project Chemist and Data Management (DM) support;

and additional EPA Team members as necessary to assist with sample collection, sample preparation, and packing.

The EPA Team PTL will be responsible for the technical quality of work performed in the field and will serve as the EPA Team liaison to the EPA Task Order Monitor (TOM) during the field activities. The PTL, with the concurrence of the EPA TOM, will determine the precise location for sample collection in the field, collect samples as necessary, log the activities at each sample location in the field logbook, and verify the sample documentation. The DM will be responsible for entering all samples collected into the Scribe Environmental Sampling Data Management System (SCRIBE), producing accurate chain-of-custody documentation for the samples during the investigation, and preparing daily reports for EPA TOM review. The PTL will oversee the packaging and shipping of samples to the designated subcontracted laboratories. The PTL will also be responsible for providing overall site health and safety support during field activities.

1.3 QASP FORMAT

This QASP is organized as follows:

- Section 1 – Introduction
- Section 2 – Site Background
- Section 3 – Field Investigation
- Section 4 – Analytical Approach and Data Validation
- Section 5 – Quality Assurance

All figures are provided as separate portable document format (PDF) files.

2. SITE BACKGROUND

Information regarding the site location, description, and geological setting, including operational history and ownership, is presented in the following subsections. This information was obtained from the New Mexico Environment Department (NMED) Groundwater Quality Bureau document titled *Site Inspection Report Phase 2, San Mateo Creek Basin, Legacy Uranium Mine and Mill Site Area, Cibola-McKinley Counties, New Mexico, dated April 2012.*

2.1 SITE LOCATION AND DESCRIPTION

The San Mateo Creek Basin, by which the boundary of the Site is defined, comprises approximately 320 square miles within the Rio San Jose drainage basin in McKinley and Cibola Counties, New Mexico. This basin is located within the Grants Mining District (GMD), which is an area of uranium mineralization occurrence approximately 100 miles long and 25 miles wide encompassing portions of McKinley, Cibola, Sandoval, and Bernalillo counties and includes the Ambrosia Lake Mining District. Main access into the Site is provided via New Mexico State Roads 605 and 509.

There are 85 legacy uranium mines with recorded production and four legacy uranium mill sites within the San Mateo Creek Basin. Twenty-two mine operations were conducted by Kerr McGee in the Ambrosia Lake area of the basin. Most of these legacy mines were operated as wet mines, where the underground workings were dewatered and the collected mine water discharged to nearby surface drainage features such as creeks and arroyos. The mine discharge water within the drainage features infiltrated into the soils and sediment and significantly re-saturated portions of the alluvium and underlying bedrock aquifers throughout the basin. Tailing liquids from the former uranium mills also seeped downward into the alluvium and underlying bedrock aquifers. These operations may have contributed to degradation of the groundwater quality within the basin. Some background groundwater contaminant concentrations associated with remediation of the Homestake Mining Company (HMC) Superfund Site exceed federal and state drinking water standards as well as state groundwater standards.

2.2 GEOLOGIC SETTING

The alluvial system extends from the northeast to south of the HMC Site, following the San Mateo Creek drainage pathway. The southern end of the San Mateo Alluvial system has been impacted by contamination from the HMC Site. Underlying the alluvial aquifer in this vicinity is the Upper Triassic Chinle Formation, which is a predominantly shale formation 800 feet in thickness. Three aquifer units are present within this formation in the southern part of the basin. The highest two aquifers are the Upper and Middle Chinle sandstones. The lower aquifer, the Lower Chinle, is fractured shale with variable hydrologic yield of generally poor quality water. All three of these aquifers subcrop with the alluvial aquifer connecting the alluvial aquifer and each of the Chinle aquifers hydrologically in the vicinity of the HMC site. The San Andres regional aquifer underlies the Chinle Formation in this area.

Most uranium production in New Mexico has come from the Upper Jurassic Westwater Canyon member of the Morrison Formation north of the HMC site in McKinley and Cibola counties. This unit consists of interbedded sandstone, claystone, and mudstone with an average thickness of 250 feet, thinning to 100 feet southward and westward, and is a major aquifer with the GMD. Three types of uranium deposits that are found in the Westwater Canyon member are primary (trend or tabular; average ore grade greater than 0.20% uranium oxide [U_3O_8], redistributed [stack; average grade 0.16% U_3O_8]), and remnant-primary (average grade 0.20% [U_3O_8]). The overlying Brushy Basin member of the Westwater Canyon member includes the Poison Canyon Sandstone from which uranium also has been mined.

Additionally, uranium deposits were discovered at Haystack Butte in 1950 within the Upper Jurassic Todilto Limestone, which occurs within the San Raphael Group underlying the Morrison Formation; these accounted for approximately 2% of production from the Grants Uranium District between 1950 and 1981. More than 100 uranium mines and occurrences in the Todilto Limestone are documented in New Mexico, with production reported from 42 of these mines - mostly located within the Grants Uranium District.

Thin zones of minor uranium mineralization have been produced from shale and lignite within the Lower Cretaceous Dakota Sandstone, which overlies the Morrison Formation. Quaternaryage unconsolidated to semi-consolidated alluvial, eolian, and terrace deposits overlie bedrock in valley bottoms; these deposits are generally less than 200 feet in thickness.

Information cited in *Principal Aquifers and Uses of Water between Laguna Pueblo and Gallup, Valencia, and McKinley Counties, New Mexico*, suggests that the Dakota Sandstone of the Cretaceous age consists of yellowish-brown to gray, quartz sandstone with local beds and lenses of conglomerate and coal. Generally, the sandstone is firmly cemented with silica and fractures are abundant locally. The Dakota Sandstone ranges in thickness from 50 to 250 feet within the area and contains water where it lies below the water table. In the eastern part of the Ambrosia Lake region, several mine shafts encountered water in the Dakota in quantities large enough to create dewatering problems. Within most of the area where the Dakota is an aquifer, it is under artesian pressure and well yields are in the range of 1 to 10 gallons per minute (gpm).

Information provided below was taken from the *Hydrogeology of Cibola County, New Mexico*, U.S. Geological Survey Water-Resources Investigations Report 94-4178 (1995); this report suggests that the Glorieta Sandstone is present in most of Cibola County except along the western flank of the Lucero Uplift and in the Zuni Mountains area. The Glorieta Sandstone conformably overlies the Yeso Formation. The contact between the two units is gradational and sometimes difficult to determine. In the Grants-Bluewater area, the Glorieta Sandstone consists of about 86 to 300 feet of massive, well-sorted, fine- to medium-grained sandstone. The basal part of the unit may contain some silty beds, and calcareous or silica cement is present throughout. In the southeastern part of the county, the Glorieta Sandstone consists of 135 to 200 feet of buff, well-sorted quartzose sandstone.

The San Andres Limestone conformably overlies the Glorieta Sandstone. Some places have extensive intertonguing of the San Andres Limestone with the Glorieta Sandstone. In the Grants-Bluewater area, the San Andres ranges from 80 to 150 feet in thickness. The unit thickens toward the southeastern part of the county where a sequence of evaporite deposits is present in the lower part of the formation.

The San Andres Limestone varies in lithology throughout the county. Gordon (1961, p. 27) described three units in the Grants-Bluewater area: a lower massive limestone that may contain interbedded sandstone and limestone, a middle medium-grained sandstone, and an upper massive fossiliferous limestone. Jicha (1958, p. 15) divided the formation into two members in the southern part of the Lucero Uplift. A lower evaporite member, 300 to 325 feet thick, consists of thick beds of gypsum, shale, limestone, and sandstone. An upper limestone member, 100 to 125 feet thick, consists of thin to massive-bedded gray limestone.

2.3 OPERATIONAL HISTORY AND OWNERSHIP

Uranium ore was discovered in the Todilto Limestone at Haystack Butte in 1950, and production began prior to mill construction in the area by open-pit mining. Uranium was discovered at Ambrosia Lake in 1955. Downdip drilling from the initial surface discoveries delineated ore bodies within the Poison Canyon and Westwater Canyon members of the Morrison Formation. The discovery of large subsurface uranium deposits within the Westwater Canyon member resulted in the establishment of two-thirds of the active uranium mines in New Mexico within the Ambrosia Lake district by 1980; most of these mines were underground room-and-pillar operation at depths averaging 900 feet.

The Anaconda Copper Company built the Bluewater Mill in 1953 to process ore from the Jackpile Mine. This mill used a carbonate-leach process with a capacity of 300 tons per day and operated until 1959. An acid-leach mill was operated from 1957 through 1982, reaching a production capacity of 6,000 tons per day in 1978. Atlantic Richfield Company (ARCO) reclaimed the site between 1991 and 1995 for long-term stewardship under the Department of Energy’s (DOE’s) Legacy Management Program.

Two mills were built in 1957 at the present Homestake Mill Site. The first closed in 1962. Homestake originally owned the second larger mill in a partnership. When that partnership was dissolved in 1981, Homestake became the sole owner. Mill production ceased in 1981, but resumed in 1988 to process ore from the Section 23 Mine and Chevron’s Mount Taylor Mine. The mill was demolished in 1990, and the site groundwater restoration is ongoing. In 2001, Homestake merged with Barrick Gold Corporation.

Kermac Nuclear Fuels Corp., which was a partnership of Kerr-McGee Oil Industries, Inc., Anderson Development Corp., and Pacific Uranium Mines Co., built the Kerr-McGee Uranium Mill at Ambrosia Lake in 1957-58. Quivira Mining Co., a subsidiary of Kerr-McGee Corp. (later Rio Algom Mining LLC, currently BHP-Billiton), became the operator of the mill in 1983. Operation began in 1958; from 1985 through 2002, the mill extracted uranium from mine water from the Ambrosia Lake underground mines. The tailing impoundment at the site contains 33 million tons of uranium ore (*sic*) within an area of 370 acres.

Phillips Petroleum Co. built a mill at Ambrosia Lake in 1957-58 and began to process ore from the Ann Lee, Sandstone, and Cliffside mines in 1958. United Nuclear Corporation acquired the property in 1963 when the mill closed. United Nuclear Corporation operated an ion exchange system to extract uranium from mine water in the late 1970s to early 1980s. All operations ended in 1982.

3. FIELD INVESTIGATION

The activities that will be conducted during the groundwater investigation are discussed in this section including sampling strategy, data quality objectives, and preliminary field activities. Monitoring well installation, development, and sampling along with sampling procedures, locations, analytical approach, and quality assurance (QA) are also discussed. Relevant Standard Operating Procedures (SOPs) are found in Appendices A and B, respectively.

3.1 SAMPLING STRATEGY

The EPA TOM and the EPA Team developed a sampling strategy intended to collect the data necessary to evaluate and meet the objective of the investigation. The objective of the investigation is to fill data gaps and assess the environmental impacts from legacy Kerr McGee mine operations by furthering the evaluation of alluvial groundwater quality and initiating the evaluation of Dakota Sandstone and SAG limestone groundwater quality within the San Mateo Creek Basin with a focus on the attribution to the former Kerr McGee Uranium Mine operations.

The sampling strategy focuses on the collection of groundwater from newly installed monitoring wells and from existing monitoring wells located in the San Mateo Creek Basin that could be impacted by former Kerr McGee Uranium Mine operations. A proposed sample location map identifying proposed alluvial, Dakota Sandstone, and SAG limestone monitoring well locations is presented on Figure 3-1.

As part of this groundwater investigation, the EPA Team plans to install up to 14 alluvial monitoring wells, seven (7) Dakota Sandstone, and one (1) SAG monitoring well. In addition, up to eight (8) existing alluvial, two (2) Dakota Sandstone, and four (4) SAG monitoring wells will be sampled during the investigation. Table 3-1 includes a summary of Sample Locations and Sampling Rationale as part of the field effort. Sample locations and coordinates of the proposed newly installed wells and existing wells are included in Table 3-2.

3.2 DATA QUALITY OBJECTIVES

The objectives of the installation of new wells and sampling of existing groundwater wells are to fill data gaps and assess the environmental impacts from legacy Kerr McGee mine operations that may affect groundwater quality within the San Mateo Creek Basin. Specifically, the objectives are: 1) to acquire groundwater quality data in areas of the basin that are currently lacking such data; 2) to attempt to characterize background (i.e., natural) concentrations of constituents of concern as well as the variability of natural and anthropogenic constituents of concern; and 3) to use the EPA Observed Release Guidance to establish whether Observed Releases of constituents of concern have occurred due to former Kerr McGee mine legacy operations. To accomplish this, a groundwater Data Quality Objective (DQO) has been developed and is included in Appendix C. The DQO presented was developed using the seven-step process set out in the EPA *Guidance for the Data Quality Objectives Process: EPA QA/G-4*.

3.3 PRELIMINARY FIELD ACTIVITIES

Mobilization and preliminary field activities for the groundwater investigation are discussed in the following subsections.

3.3.1 Field Activities Review Meeting

The EPA Team PTL will conduct a meeting with the entire field team to familiarize them with the Scope of Work, to discuss EPA TOM expectations, including planned field investigation activities, and to review the project Health and Safety Plan (HASP), radiation awareness training, and other relevant EPA Team operating procedures. This meeting will be conducted in the EPA Grants, New Mexico field office or via video conferencing for team members in other offices, prior to mobilizing to the field.

3.3.2 Mobilization and Command Post Establishment

The EPA Team will mobilize the equipment required for the field investigation from its Regional Equipment Stores (RES) warehouse in Houston, Texas.

The field team will utilize the existing EPA command post located at the intersection of Highways 605 and 509 north of Grants, New Mexico. Equipment used during the investigation will be stored in the command post. The EPA Team will provide sufficient dedicated (nondisposable and disposable) sampling equipment to collect samples in a manner minimizing the number of times that decontamination is performed on a daily basis.

Prior to demobilization, all remaining field supplies and equipment will be shipped back to RES.

3.3.3 Health and Safety Plan Implementation

The field activities will be conducted in accordance with the site-specific HASP prepared for this investigation. In general, the HASP specifies that work will proceed in Level D personal protective equipment (PPE) (coveralls, hard hats, and steel-toed boots) in selected sampling areas based on appropriate air monitoring results. The EPA Team PTL will serve as the Field Safety Officer (FSO) and will be responsible for implementation of the HASP during field investigation activities. Subcontractors participating in the groundwater investigation will be required to conduct work according to the guidelines and requirements of the HASP. Daily tailgate safety meetings will be held prior to initiation of each work day.

In accordance with the EPA Team’s general health and safety operating procedures, the field team will also drive the route to the hospital specified in the HASP prior to initiating sampling activities.

3.3.4 Sample Location Reconnaissance

The EPA Team will complete an initial survey of on-site sample locations to verify that sample monitoring well locations have been selected appropriately and choose alternative well locations if proposed locations are inaccessible or if a better sampling location can be found. The PTL will consult with the EPA TOM before selecting alternative sample locations.

3.3.5 Residential Property Access and Community Relations

Sampling may be required in locations where access has not yet been obtained prior to the field activities. If the EPA TOM is not present in the field during the field activities, the EPA PTL or Field Operations Liaison will manage community relations in the field as directed by the EPA TOM.

3.3.6 Documentation of Field Sampling Activities

The EPA Team will document the field activities in bound field logbooks. At a minimum, the information documented in the field logbook for each sample location will include the following:

- The sample location number and the depths of sample collection.
- A description of the sample location at the site.
- A measurement from the sample location to a physical structure.

- The sample matrix and sample description.
- The analyses for which the samples were collected.
- The date and time of sample collection.

Locations where samples are collected, including newly installed and existing monitoring wells, will be documented using a global positioning system (GPS) to obtain horizontal control.

3.3.7 Decontamination and Investigation-Derived Wastes (IDW)

The nondisposable sampling equipment (groundwater sampling pumps, water measurement instrumentation, etc.) used during the sample collection process will be thoroughly decontaminated before initial use, between locations, and at the end of the field investigation activities before leaving the Site. Decontamination activities will be conducted at a location designated by the EPA Team PTL. Equipment decontamination will be completed in the following steps:

- High-pressure water spray or brush, if needed, to remove soil from the equipment.
- Nonphosphate detergent and potable water wash to clean the equipment.
- Final potable water rinse.
- Equipment air dried.

Equipment used during drilling activities will be decontaminated by high-pressure steam cleaning prior to drilling and between each location. In addition to steam cleaning between drilling locations, the soil sampling equipment, such as split-spoons, core-barrel samplers, and Shelby tubes, will be high-pressure steam cleaned between each location. This equipment will then be rinsed with potable water before reuse. If deemed necessary, decontamination activities will be conducted at a temporary decontamination pad that will be constructed in an area identified prior to the beginning of field activities.

Any fluids and excess soil generated as a result of equipment decontamination will be containerized at the completion of field activities. Water and soil generated from the monitoring well installation and development activities will be containerized and transported back to the soil staging pad and appropriately disposed of at the end of the project. A detailed IDW plan is included in Appendix D.

3.4 MONITORING WELL INSTALLATION

The EPA Team will utilize a State of New Mexico-licensed driller for the monitoring well installation activities. Well installation and plugging/abandonment will be performed in accordance with any EPA and/or State of New Mexico regulations.

The EPA Team anticipates utilizing sonic and rotary drilling techniques to advance, continuously sample, and install up to 14 shallow alluvial groundwater monitoring wells estimated to be approximately 60 and 100 feet below ground surface (bgs). Up to seven (7) deep monitoring wells will be advanced into the Dakota Sandstone formation utilizing sonic drilling methods to approximately 150 feet to 250 feet bgs. One (1) deep monitoring well will be advanced to approximately 750 feet bgs into the SAG formation using air rotary or sonic drilling methods. Each boring advanced will be continuously sampled to terminal depth and classified by the EPA Team PTL according to the Unified Soil Classification System (USCS). At the completion of each boring, and as noted above, a determination will be made between the EPA TOM and the EPA Team PTL as to whether to convert the boring into a groundwater monitoring well. If sufficient groundwater is not encountered, no well will be installed, the boring will be immediately grouted as described below, and an alternate drilling location may be selected. If adequate groundwater is encountered in the borehole and a well is to be installed, the EPA TOM and EPA Team PTL will determine the appropriate screened interval based on field observations. Monitoring well installation details are described in the following subsection.

The EPA Team PTL and the subcontracted driller will work to ensure that there is no unnecessary disturbance to the local surroundings where soil borings and/or monitoring wells are to be installed. The EPA TOM and EPA Team PTL have worked to select well locations that are as close to existing roads as possible to reduce unnecessary soil and vegetative disturbance. There are no plans to build any roads to the proposed monitoring well locations. The possibility of making small improvements to some of the existing dirt roads utilizing a back-hoe or similar equipment could be conducted to level the driving surfaces and allow for drilling rig access. No well pads or mud pits will be needed as part of this groundwater investigation. Monitoring wells and/or soil borings will not be advanced on or adjacent to any steep slopes. Any soil cuttings and well development water generated as part of the investigation will be containerized and transported and managed at the soil staging pad.

In lieu of installing a monitoring well due to dry borehole conditions, the EPA TOM and EPA Team PTL may choose to collect soil cores for Synthetic Precipitation Leaching Procedure (SPLP) laboratory analyses. Specific analyses designated for these core samples are included in Section 4.0.

3.4.1 Monitoring Well Installation Details

Information regarding specific drilling and casing methods is presented in the following subsections.

3.4.1.1 Alluvial Drilling

The alluvial drilling will be completed entirely using sonic drilling. Drilling will be advanced with a nominal 6-inch borehole temporary casing and a 4-inch continuous core sampling system. After completion of the core sampling to the desired depth, the 6-inch casing will be advanced to the terminal depth. If groundwater is encountered, a 2-inch-diameter schedule 40 PVC well will be installed inside the 6-inch borehole casing. Well construction will consist of 10 feet of 0.010-inch slotted screen and blank riser to the surface. A 20/40 silica sand will be placed inside the 6-inch casing to a minimum height of 2 feet above the screen. A minimum of a 2-foot bentonite pellet seal will be placed above the sand filter pack, hydrated, and allowed to stand for a minimum of 30 minutes. A high-solids bentonite/Portland cement mixture will be used to grout the remaining portion of the annulus. During the grouting process, the 6-inch casing will be removed from the boring.

3.4.1.2 Dakota Sandstone Drilling

The Dakota Sandstone drilling will be completed entirely using sonic drilling. Drilling will be advanced with a nominal 10-inch borehole and a 6-inch continuous core sampling system. Drilling with the 10-inch borehole will be advanced through the alluvial material until competent bedrock material is identified by the EPA Team PTL. A 10-inch casing will then be seated into the bedrock material and left in place to serve as a temporary conductor casing to seal the upper zone. Drilling and sampling will continue through the temporary casing utilizing a nominal 8-inch temporary casing and a 6-inch continuous core sampling system advanced to the terminal depth. If groundwater is encountered, a 4-inch diameter schedule 40 PVC well will be installed inside the 6-inch borehole casing. Well construction will consist of 10 feet of 0.010-inch slotted screen and blank riser to the surface. A 20/40 silica sand will be placed inside the 6-inch casing to a minimum height of 2 feet above the screen. A minimum of a 2-foot bentonite pellet seal will be placed above the sand filter pack, hydrated, and allowed to stand for a minimum of 30 minutes. A high-solids bentonite/Portland cement mixture will be used to grout the remaining portion of the annulus. During the grouting process, the 8-inch and 10-inch casing will be removed from the boring.

3.4.1.3 San Andres Drilling

The San Andres drilling will be completed with a combination of sonic drilling and rotary drilling. Continuous samples will be collected from the entire length of the borehole. The rotary drill rig will then ream and set the upper 16-inch temporary conductor casing in the bedrock immediately below the alluvial material. Continuous coring will continue to a depth of approximately 600 feet. At this point, the rotary drill will ream and set 10-inch temporary isolation casing to seal off this zone. Coring will continue to an approximate depth of 700 feet or the terminal depth. The rotary drill will then ream the borehole and install 9-inch temporary casing to the terminal depth. If groundwater is encountered, a 5-inch-diameter schedule 40 PVC well will be installed inside the 6-inch borehole casing. Well construction will consist of 10 feet of 0.010-inch slotted screen and blank riser to the surface. A 20/40 silica sand will be placed inside the 6-inch casing to a minimum height of 2 feet above the screen. A minimum of a 2-foot bentonite pellet seal will be placed above the sand filter pack, hydrated, and allowed to stand for a minimum of 30 minutes. A high-solids bentonite/Portland cement mixture will be used to grout the remaining portion of the annulus. During the grouting process, the 9-inch, 10-inch, and 16-inch casing will be removed from the boring.

A 5-foot-long, 6-inch-diameter outer protective steel casing with a lockable-hinge cap will be installed 2 to 3 feet into the grout seal. The riser pipe will terminate no more than 4 inches below the rim of the protective casing. A 4-foot by 4-foot concrete pad will be installed around the outer base of the protective casing. A typical well construction schematic is included as Figure 3-2.

3.4.2 Well Geophysical Logging

Prior to initiating drilling activities associated with the SAG well installation, the EPA Team will conduct cased-well geophysical logging to obtain lithology information including thickness of major geologic units and depth and character (orientation) of water-bearing fractures of a nearby SAG well. The well logging will consist of one or more of the following suites of geophysical logs: 3-Arm caliper, single-point resistance, temperature, spontaneous potential (SP), natural gamma, and acoustic televiewer (oriented). A quality assurance/re-run log will be conducted to assure the quality of the data from the geophysical logging. The re-run log will be repeated in a section of at least 100 feet, through a section of the well selected by the EPA Team PTL. It is anticipated that the re-run logs would be conducted through a section of the well in which the formation contact between the Chinle mudstone/siltstone formation and the underlying San Andres limestone occurs. If the logs for the repeat section do not correlate with the initial logs for the same borehole interval, the geophysical logging tools will be recalibrated and the entire borehole will be re-logged.

Geophysical logging of the seven (7) newly installed Dakota Sandstone monitoring wells and one (1) SAG will also be conducted using the same geophysical methods noted above to confirm bedrock lithologic information.

3.4.3 Plugging and Abandonment

Boreholes that do not produce sufficient water will be grouted according to State of New Mexico regulations. All borehole grouting will be conducted using a minimum of grout mixture consisting of 6 to 8 pounds of bentonite powder per 94-pound bag of Portland cement, mixed with 6 to 8 gallons of water. The boreholes will be pressure grouted using a tremie pipe from the bottom to the ground surface. The tremie pipe/hose will be placed at the bottom of the borehole and raised at a rate so that the bottom of the tremie pipe remains below the top of the grout.

3.5 MONITORING WELL DEVELOPMENT

The newly installed monitoring wells will be developed no sooner than 24 hours after completion using a submersible pump and dedicated tubing or other means deemed appropriate by the EPA Team PTL and EPA TOM. The submersible pump used for well development will initially be set at the bottom of the well, then slowly moved toward the top of the screen or borehole to ensure that water is drawn through all portions of the screened interval. During well development activities, the EPA Team PTL will collect and record in the logbook well purging information including field measurements of groundwater dissolved oxygen (DO), turbidity, pH, electrical conductivity (EC), temperature, and oxidation/reduction potential (ORP).

3.6 MONITORING WELL SAMPLING

Each newly installed and existing monitoring well will be sampled following EPA *Low-flow (Minimal-Drawdown) Groundwater Sampling Procedures* (EPA/540/S-95/504, April 1996) (Appendix A).

The EPA Team will measure depth to groundwater in each well and then utilize a monsoon pump, or appropriate pump that meets depth requirements, with dedicated sample tubing to collect groundwater samples. During well sampling, field measurements of groundwater DO, turbidity, pH, EC, temperature, and ORP will be collected and recorded in the field logbook.

The groundwater samples will be submitted to a National Environmental Laboratory Accreditation Program (NELAP)-certified laboratory for analyses. Specific laboratory information is included in Section 4.0 of this QASP.

3.7 LOCATION AND ELEVATION SURVEY

The EPA Team will survey the newly installed Dakota Sandstone and SAG monitoring well utilizing Online Positioning User Service (OPUS) technology. OPUS is a free, web-based service developed and maintained by the National Oceanic and Atmospheric Administration (NOAA)'s National Geodetic Survey (NGS). The service provides simplified access to high-accuracy National Spatial Reference System (NSRS) coordinates which is used to compute precise horizontal and vertical measurements from data collected with a survey-grade GPS receiver.

The OPUS-Static method using a Trimble R8 GPS Receiver with tripod will be used by the EPA Team to collect natural ground elevations at each well location. Since length of occupation is one of the most important contributors to vertical accuracy, a 2-hour observation per well location will be used. The expected vertical and horizontal accuracy per well will be 2.5 centimeters and 1.5 centimeters, respectively.

GPS observation data per well will be uploaded to the OPUS online system (http://www.ngs.noaa.gov/OPUS/). High-accuracy positions will be returned via email once the post-processing of the data is complete, generally 30 minutes up to 24 hours.

Relative Top of Casing (TOC) measurements will be collected manually using chalked steel tape for wells with casings extending above the natural ground surface. Relative TOC measurements will be added to the OPUS post-processed natural ground elevations in order to calculate an absolute TOC elevation per well.

3.8 DEVIATIONS FROM THE SAMPLING PLAN

Deviations from the sample locations may occur at the EPA TOM’s direction due to new observations made prior to sampling, information obtained in the field that warrants an altered sampling point, difficulty in sample collection, or limited access. The EPA TOM will be notified, and concurrence will be obtained should significant deviations from the planned sampling points be proposed. Details regarding deviations of the QASP will be documented in the site logbook and reported in the final report to EPA.

Table 3-1
Sample Locations and Sampling Rationale
Tronox Mine Sites R6/R9
Cibola and McKinley Counties, New Mexico

Sample Name	Sample Matrix	Sample Location (Refer to Figure 3-1)	Rationale
N-5	Groundwater	Drill a monitoring well west of the Chill Willis Mine.	Collected to determine alluvial groundwater quality, dry soil may be collected to determine impact to lithology
N-6	Groundwater	Drill a monitoring well located in Section 16 south of existing C-5 location.	Collected to determine alluvial groundwater quality, dry soil may be collected to determine impact to lithology
N-7	Groundwater	Drill a monitoring well located in San Mateo Creek at the border of Section 15 and Section 22.	Collected to determine alluvial groundwater quality, dry soil may be collected to determine impact to lithology
N-8	Groundwater	Drill a monitoring well located in Section 21 north of Hwy 605.	Collected to determine alluvial groundwater quality, dry soil may be collected to determine impact to lithology
N-9	Groundwater	Drill a monitoring well located in Section 6 along the San Mateo Creek.	Collected to determine alluvial groundwater quality, dry soil may be collected to determine impact to lithology
N-10	Groundwater	Drill a monitoring well in Section 6 and north of San Mateo Creek.	Collected to determine alluvial groundwater quality, dry soil may be collected to determine impact to lithology
N-11	Groundwater	Drill a monitoring well in Section 6 and south of San Mateo Creek bifurcation.	Collected to determine alluvial groundwater quality, dry soil may be collected to determine impact to lithology
N-12	Groundwater	Drill a monitoring well in Section 1 in San Mateo Creek west of Hwy 605.	Collected to determine alluvial groundwater quality, dry soil may be collected to determine impact to lithology
N-13	Groundwater	Drill a monitoring well in Section 1 in San Mateo Creek south on N-12.	Collected to determine alluvial groundwater quality, dry soil may be collected to determine impact to lithology

Table 3-1
Sample Locations and Sampling Rationale
Tronox Mine Sites R6/R9
Cibola and McKinley Counties, New Mexico
(Continued)

Sample Name	Sample Matrix	Sample Location (Refer to Figure 3-1)	Rationale
N-14	Groundwater	Drill a monitoring well in Section 12 in San Mateo Creek west of SMC 12.	Collected to determine alluvial groundwater quality, dry soil may be collected to determine impact to lithology
N-15	Groundwater	Drill a monitoring well in Section 12 in San Mateo Creek south of N-14.	Collected to determine alluvial groundwater quality, dry soil may be collected to determine impact to lithology
N-16	Groundwater	Drill a monitoring well in Section 12 in San Mateo Creek west of SMC-10 and west of Hwy 605.	Collected to determine alluvial groundwater quality, dry soil may be collected to determine impact to lithology
N-17	Groundwater	Drill a monitoring well west of SMC-13.	Collected to determine alluvial groundwater quality, dry soil may be collected to determine impact to lithology
N-18	Groundwater	Drill a monitoring well west of SMC-14.	Collected to determine alluvial groundwater quality, dry soil may be collected to determine impact to lithology
NKD-01	Groundwater	Drill a monitoring well located north-northeast of the Section 22 Mine.	Collected to determine Dakota Sandstone groundwater quality, dry soil may be collected to determine impact to lithology
NKD-02	Groundwater	Drill a monitoring well located in Section 13, west of Hwy 509.	Collected to determine Dakota Sandstone groundwater quality, dry soil may be collected to determine impact to lithology
NKD-03	Groundwater	Drill a monitoring well located southwest of the Section 26 Mine.	Collected to determine Dakota Sandstone groundwater quality, dry soil may be collected to determine impact to lithology
NKD-04	Groundwater	Drill a monitoring well located west of existing Dakota Sandstone Well 36-06 KD.	Collected to determine Dakota Sandstone groundwater quality, dry soil may be collected to determine impact to lithology
NKD-05	Groundwater	Drill a monitoring well located south of the Section 33 Mine.	Collected to determine Dakota Sandstone groundwater quality, dry soil may be collected to determine impact to lithology

Table 3-1
Sample Locations and Sampling Rationale
Tronox Mine Sites R6/R9
Cibola and McKinley Counties, New Mexico
(Continued)

Sample Name	Sample Matrix	Sample Location (Refer to Figure 3-1)	Rationale
NKD-06	Groundwater	Drill a monitoring well located near existing well MW-35-9.	Collected to determine Dakota Sandstone groundwater quality, dry soil may be collected to determine impact to lithology
NKD-07	Groundwater	Drill a monitoring well located west of the Chill Willis Mine.	Collected to determine Dakota Sandstone groundwater quality, dry soil may be collected to determine impact to lithology
SAG-01	Groundwater	Drill a monitoring well located in the middle of Section 12 west of Hwy 605.	Collected to determine San Andres-Glorieta groundwater quality, dry soil may be collected to determine impact to lithology
MW-35-8	Groundwater	Sample existing monitoring wells located south of Cliffside, Sandstone, and Section 35 Mines.	Collected to determine alluvial groundwater quality
MW-35-9	Groundwater	Sample existing monitoring wells located south of Cliffside, Sandstone, and Section 35 Mines.	Collected to determine alluvial groundwater quality
SMC-23	Groundwater	Sample existing monitoring well located west of Marquez Mine.	Collected to determine bedrock groundwater quality
SMC-24	Groundwater	Sample existing monitoring well located west of Marquez Mine.	Collected to determine bedrock groundwater quality
SMC-26	Groundwater	Sample existing monitoring well located west of Marquez Mine.	Collected to determine alluvial groundwater quality
C-3	Groundwater	Sample existing Well C-3 located north of Moe No. 4 Mine.	Collected to determine alluvial groundwater quality
N-3	Groundwater	Sample existing Well N-3 located in Section 25.	Collected to determine alluvial groundwater quality
BG-03	Groundwater	Sample existing Well BG-03.	Collected to determine alluvial groundwater quality
BG-04	Groundwater	Sample existing Well BG-04.	Collected to determine alluvial groundwater quality
BG-05	Groundwater	Sample existing Well BG-05.	Collected to determine alluvial groundwater quality

Table 3-1
Sample Locations and Sampling Rationale
Tronox Mine Sites R6/R9
Cibola and McKinley Counties, New Mexico
(Continued)

Sample Name	Sample Matrix	Sample Location (Refer to Figure 3-1)	Rationale
SAG PV	Groundwater	Sample existing private well north of N-10.	Collected to determine San Andres-Glorieta groundwater quality
907	Groundwater	Sample existing Well 907 located in Section 4 south of Homestake Mill site.	Collected to determine San Andres-Glorieta groundwater quality
943	Groundwater	Sample existing Well 907 located in Section 34 south of Homestake Mill site.	Collected to determine San Andres-Glorieta groundwater quality
928	Groundwater	Sample existing Well 907 located in Section 23 north of Homestake Mill site.	Collected to determine San Andres-Glorieta groundwater quality

Table 3-2
Sample Locations and Coordinates
Tronox Mine Sites R6/R9
Cibola and McKinley Counties, New Mexico

WELL	LATITUDE	LONGITUDE
BG-03	35.3363	-107.6545
BG-04	35.3408	-107.6524
BG-05	35.3425	-107.6513
NKD-01	35.4423	-107.8714
NKD-02	35.4368	-107.8464
NKD-03	35.4119	-107.8716
NKD-04	35.3974	-107.8580
NKD-05	35.3964	-107.7916
NKD-06	35.3716	-107.7655
NKD-07	35.3463	-107.7522
SAG-1	35.3082	-107.8271
SAG PV	35.2829	-107.8425
907	35.2179	-107.8978
928	35.2521	-107.8630
943	35.2252	-107.8761
N-3	35.4351	-107.8439
N5	35.3464	-107.7496
N-6	35.4361	-107.8096
N-7	35.3483	-107.7841
N-8	35.3436	-107.7908
N-9	35.3291	-107.8036
N-10	35.3048	-107.8260
N-11	35.3014	-107.8218
N-12	35.3004	-107.8386
N-13	35.2955	-107.8389
N-14	35.2824	-107.8507
N-15	35.2766	-107.8381
N-16	35.3461	-107.7496
N-17	35.2750	-107.8542

Table 3-2
Sample Locations and Coordinates
Tronox Mine Sites R6/R9
Cibola and McKinley Counties, New Mexico
(Continued)

WELL	LATITUDE	LONGITUDE
N-18	35.2749	-107.8639
C-3	35.3150	-107.8125
MW-35-8	35.3793	-107.7630
MW-35-9	35.3744	-107.7677
SMC-23	35.3451	-107.7860
SMC-24	35.3445	-107.7851
SMC-26	35.3465	-107.7746

4. ANALYTICAL APPROACH AND DATA VALIDATION

Groundwater and soil samples collected as part of the field effort will be analyzed for radiological, stable isotope and chemical analyses by a NELAP-certified laboratory. Table 4-1 summarizes the samples that will be collected, including the volumes, container types, and associated analytical methods.

4.1 RADIOLOGICAL ANALYSES

Groundwater samples collected will be submitted for the following radiological analyses:

- Total Uranium
- Dissolved Uranium
- Isotopic Thorium (Alpha Spectrometry): Th-227, Th-228, Th-230, Th-232
- Isotopic Uranium (Alpha Spectrometry): U-234, U-235, U-236, U-238
- Gamma Spec: Ra-226, Ra-228
- Gross Alpha/Beta

4.2 STABLE ISOTOPE ANALYSES

Groundwater samples collected will be submitted for the following stable isotopes analyses:

- Carbon 13 (^{13}C)
- Deuterium (^{2}H)
- Oxygen 18 (^{18}O)
- Sulfur (^{34}S)

4.3 CHEMICAL ANALYSES

Groundwater samples collected will be submitted for the following chemical analyses:

- Total Metals and Mercury
- Dissolved Metals and Mercury
- Total Dissolved Solids (TDS)
- Anions, alkalinity, carbonate, and bicarbonate
- pH

Up to 25 soil core samples collected will be submitted for Synthetic Precipitation Leaching Procedure (SPLP) extraction followed by total metals and radiological analyses.

4.4 DATA VALIDATION

The EPA Team will validate the radioanalytical data by having each data set reviewed by a professional certified health physicist (CHP). A summary of the data validation and findings will be presented in Summary Reports as part of the final report. The EPA Team will evaluate the following to verify that the radioanalytical data are within acceptable QA/QC tolerances:

- The completeness of the laboratory reports, verifying that all required components of the report are present and that the samples indicated on the accompanying chain-of-custody are addressed in the report.
- The results of laboratory blank analyses.
- The results of laboratory control sample (LCS) analyses.
- Compound identification and quantification accuracy relative to expected isotopic ratios for uranium and its decay products.
- Laboratory precision, through review of the results for blind field duplicates.

The inorganic analytical data generated by the designated laboratory will be validated using EPA-approved data validation procedures in accordance with the EPA *National Functional Guidelines for Inorganic Superfund Data Review* (August 2014). A summary of the data validation findings will be presented in Data Validation Summary Reports as part of the final report. The following will be evaluated to verify that the analytical data is within acceptable QA/QC tolerances:

- The completeness of the laboratory reports, verifying that all required components of the report are present and that the samples indicated on the accompanying chain-of-custody are addressed in the report.
- The calibration and tuning records for the laboratory instruments used for the sample analyses.
- The results of internal standards analyses.
- The results of laboratory blank analyses.
- The results of LCS analyses.
- The results of MS/MSD analyses.
- Compound identification and quantification accuracy.

- Laboratory precision, by reviewing the results for blind field duplicates.

Variances from the QA/QC objectives will be addressed as part of the Data Validation Summary Reports.

Table 4-1
Requirements for Containers, Preservation Techniques, Sample Volumes, and Holding Times
Tronox Mine Sites R6/R9
Cibola and McKinley Counties, New Mexico

Name	Methods	Container	Preservation	Minimum Sample Volume	Maximum Holding Time
TAL Metals and Mercury	SW-846/6020 and 7470A	Polyethylene	HNO_3	250 mL	28 days for mercury 180 days for metals
TAL Metals and Mercury (dissolved)	SW-846/6020 and 7470A	Polyethylene	HNO_3 (After being field filtered)	250 mL	28 days for mercury 180 days for metals
Total Uranium	SW-846/Method 6020	Polyethylene	HNO_3	250 mL	6 months
Total Uranium (dissolved)	SW-846/Method 6020	Polyethylene	HNO_3 (After being field filtered)	250 mL	6 months
Anions	EPA 300.0/9056	Polyethylene	4 °C	250 mL	48 hours (for nitrate, nitrite, and phosphate) / 28 days
pH	EPA 150.1/9040B/9045C	Polyethylene	4 °C	250 mL	Immediately after receipt at the laboratory
Total Dissolved Solids (TDS)	EPA 160.1/SM2540C	Polyethylene	4 °C	250 mL	7 days
Alkalinity, carbonate, and bicarbonate	EPA 310.1m/SM2320Bm	Polyethylene	4 °C	250 mL	7 days
Isotopic Uranium (Alpha Spectrometry) U-233/234, U-235/236 U-238	ASTM D3972-90M	Polyethylene	HNO_3	1 liter	180 days
Isotopic Thorium (Alpha Spectrometry): Th-228, Th-230, Th-232, Th-227	ASTM D3972-90M	Polyethylene	HNO_3	1 liter	180 days
Gross Alpha/Beta	EPA 900.0/9310	Polyethylene	HNO_3	500 mL	180 days

Table 4-1
Requirements for Containers, Preservation Techniques, Sample Volumes, and Holding Times
Tronox Mine Sites R6/R9
Cibola and McKinley Counties, New Mexico
(Continued)

Name	Method	Container	Preservation	Minimum Sample Volume	Maximum Holding Time
Radium 226	EPA 903.0/9315	Polyethylene	HNO_3	500 mL	180 days
Radium 228	EPA 903/9320	Polyethylene	HNO_3	500 mL	180 days
^{13}C	Dissolved Inorganic Carbon (DIC) via Thermo GasBench II	Glass with Polyseal conical cap	N/A	1 liter	Upon receipt at the laboratory
^{2}H	Picarro cavity ringdown spectrometer (CRDS)	Glass with Polyseal conical cap	N/A	60 ml	Upon receipt at the laboratory
^{18}O	Picarro cavity ringdown spectrometer (CRDS)	Glass with Polyseal conical cap	N/A	60 ml	Upon receipt at the laboratory
^{34}S	Barium sulfate precipitation technique	Glass or Polyethylene	N/A	1 liter	Upon receipt at the laboratory
SPLP – Radium 226	SW-846/1312/9315	Polyethylene	4 °C	100 grams	180 days
SPLP – Radium 228	SW-846/1312/9320	Polyethylene	4 °C	100 grams	180 days
SPLP – TAL Metals + Hg	SW-846/1312/6020/7470	Polyethylene	4 °C	100 grams	180 days
SPLP – Isotopic Thorium (Th-228, Th-230, Th-232, Th-227)	EPA 903.0/9315	Polyethylene	4 °C	100 grams	180 days

Table 4-1
Requirements for Containers, Preservation Techniques, Sample Volumes, and Holding Times
Tronox Mine Sites R6/R9
Cibola and McKinley Counties, New Mexico
(Continued)

Name	Method	Container	Preservation	Minimum Sample Volume	Maximum Holding Time
SPLP – Isotopic Uranium U-233/234, U-235/236 U-238	EPA 904.0/9320	Polyethylene	4 °C	100 grams	180 days

Note:
[1]Field duplicate sample will be collected at a rate of 1 per 10 samples collected.
[2]Equipment rinsate samples will be collected at the rate of 1 per week of non-disposable sampling equipment during drilling activities.
[3]MS/MSD samples will be collected at a rate of 1 per 20 samples collected.

5. QUALITY ASSURANCE

Quality assurance will be conducted in accordance with the WESTON Corporate Quality Management Manual, dated March 2014; the WESTON Programmatic Quality Assurance Project Plan (QAPP), dated December 2009; and the WESTON Quality Management Plan, dated June 2010. Following receipt of the TDD from EPA, a Quality Control (QC) officer is assigned and monitors work conducted throughout the entire project including reviewing interim report deliverables and field audits. The EPA Team PTL will be responsible for QA/QC of the field investigation activities. The designated laboratory utilized during the investigation will be responsible for QA/QC related to the analytical work. The EPA Team will also collect samples to verify that laboratory QA/QC is consistent with the required standards and to validate the laboratory data received as described above.

5.1 DATA VALIDATION

After sample collection and identification, samples will be maintained under chain-of-custody (COC) procedures. If the sample collected is to be split (laboratory QC), the sample will be allocated into similar sample containers. Sample labels completed with the same information as that on the original sample container will be attached to each of the split samples. Personnel required to package and ship coolers containing potentially hazardous material will be trained accordingly.

The EPA Team will prepare and complete chain-of-custody forms using SCRIBE for samples sent to an off-site laboratory. The chain-of-custody procedures are documented and will be made available to personnel involved with the sampling. A typical chain-of-custody record will be completed each time a sample or group of samples is prepared for shipment to the laboratory. The record will repeat the information on each sample label and will serve as documentation of handling during shipment. A copy of this record will remain with the shipped samples at all times, and another copy will be retained by the member of the sampling team who originally relinquished the samples. At the completion of the project, the Data Manager will export the SCRIBE chain-of-custody documentation to the Analytical Service Tracking System (ANSETS) database.

Samples relinquished to the participating laboratories will be subject to the following procedures for transfer of custody and shipment:

- Samples will be accompanied by the COC record. When transferring possession of samples, the individuals relinquishing and receiving the samples will sign, date, and note the time of the sample transfer on the record. This custody records document transfer of sample custody from the sampler to another person or to the laboratory.

- Samples will be properly packed for shipment and dispatched to the appropriate laboratory for analysis with separate, signed custody records enclosed in each sample box or cooler. Sample shipping containers will be custody-sealed for shipment to the laboratory. The preferred procedure includes use of a custody seal wrapped across filament tape that is wrapped around the package at least twice. The custody seal will then be folded over and adhered to seal and ensure that the only access to the package is by cutting the filament tape or breaking the seal to unwrap the tape.

- If sent by common carrier, a bill of lading or airbill will be used. Bill of lading and airbill receipts will be retained in the project file as part of the permanent documentation of sample shipping and transfer.

5.2 PROJECT DOCUMENTATION

Documents will be completed legibly in ink and by entry into field logbooks and SCRIBE as described above. Response Manager will be used at the direction of the EPA TOM.

5.2.1 Custody Seal

Custody seals demonstrate that a sample container has not been tampered with or opened. The individual who has custody of the samples will sign and date the seal and affix it to the container in such a manner that it cannot be opened without breaking the seal.

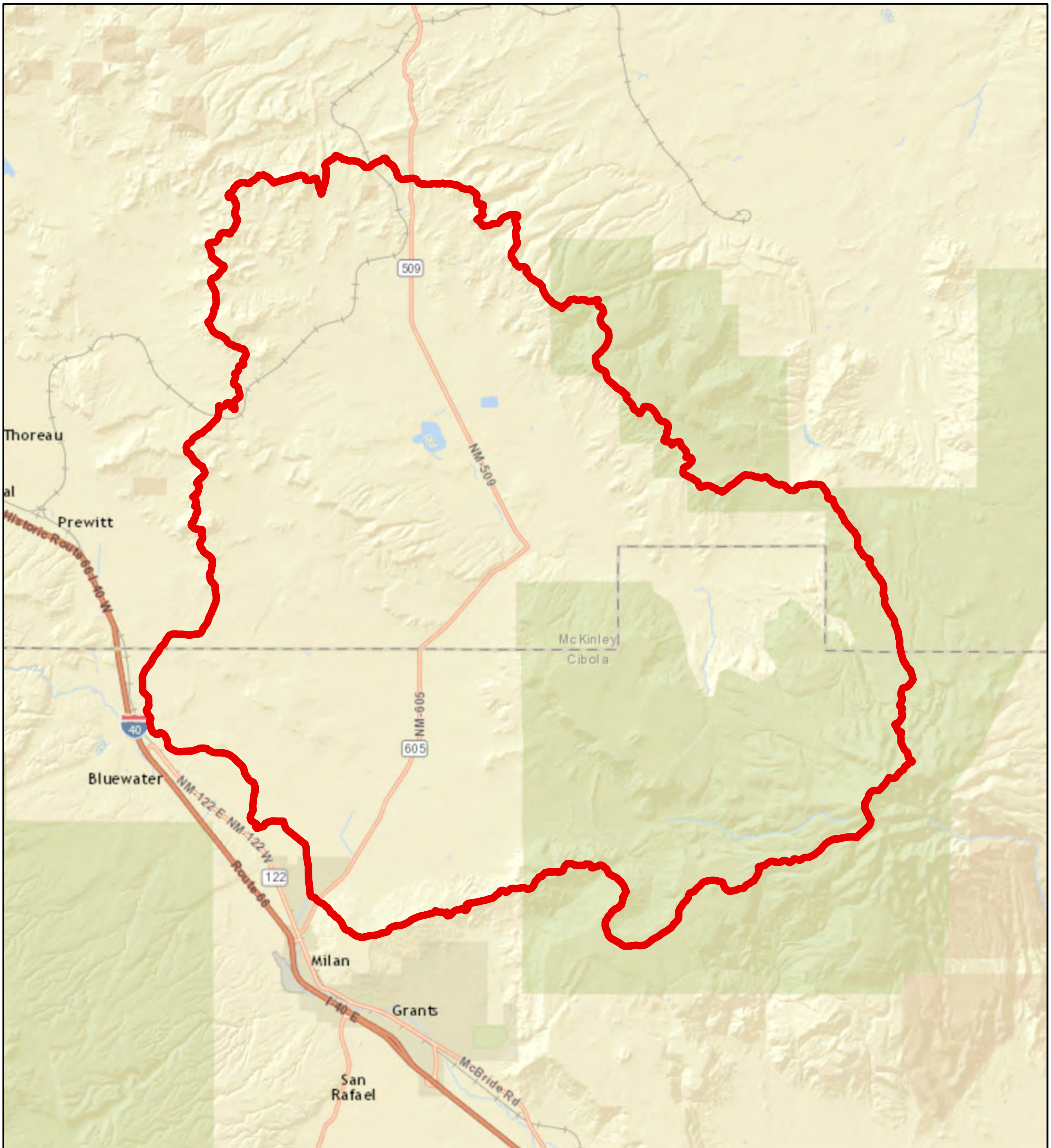
5.2.2 Photographic Documentation

The EPA Team will take photographs to document site conditions and activities as site work progresses. Initial conditions should be well documented by photographing features that define the working conditions. Representative photographs should be taken of each type of site activity. The photographs should show typical operations and operating conditions as well as special situations and conditions that may arise during site activities. Site final conditions should also be documented as a record of how the site appeared at completion of the work.

Photographs will be taken using digital cameras capable of recording the date, time, and location. Each photograph will be recorded in the logbook with the location of the photographer, direction the photograph was taken, the subject of the photograph, and its significance (i.e., why the picture was taken).

5.2.3 Report Preparation

At the completion of the project, the EPA Team will review and validate laboratory data and prepare a draft report of field activities and analytical results for EPA TOM review. Draft deliverable documents will be uploaded to the EPA TeamLink Web site for EPA TOM review and comment.



0 3 6

Miles

LEGEND

San Mateo Drainage Basin

New Mexico

N

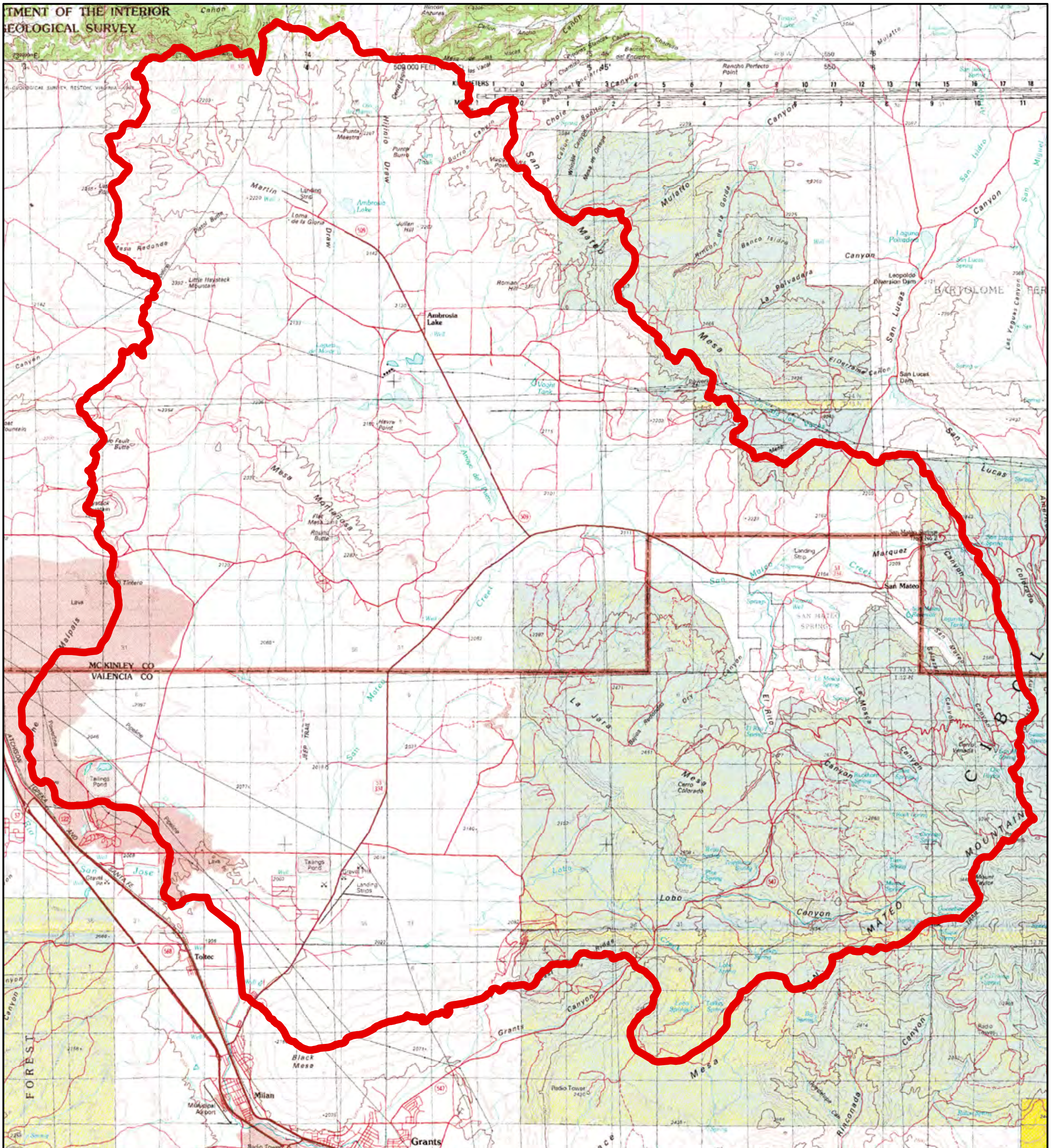
US EPA REGION 6

FIGURE 1-1
SITE LOCATION MAP
TRONOX MINE SITES
R6/R9
HWY 509 AND 605
CIBOLA & MCKINLEY COUNTIES,
NEW MEXICO

DATE	PROJECT NO	SCALE
APRIL, 2015	20406.012.019.0930.01	AS SHOWN

CERCLIS ID: NMN000606847
TDD NO: 19/WESTON-042-15-004
SOURCE: Esri World Street Map, 2015

FILE: L:\20406_START3_R6\TRONOX_MINE_ASSESSMENTS\GIS\Figure 1-1 Site Location Map_150513.mxd 3:11:36 PM 5/28/2015 wilderj



0 3 6
Miles

LEGEND
San Mateo Drainage Basin

N

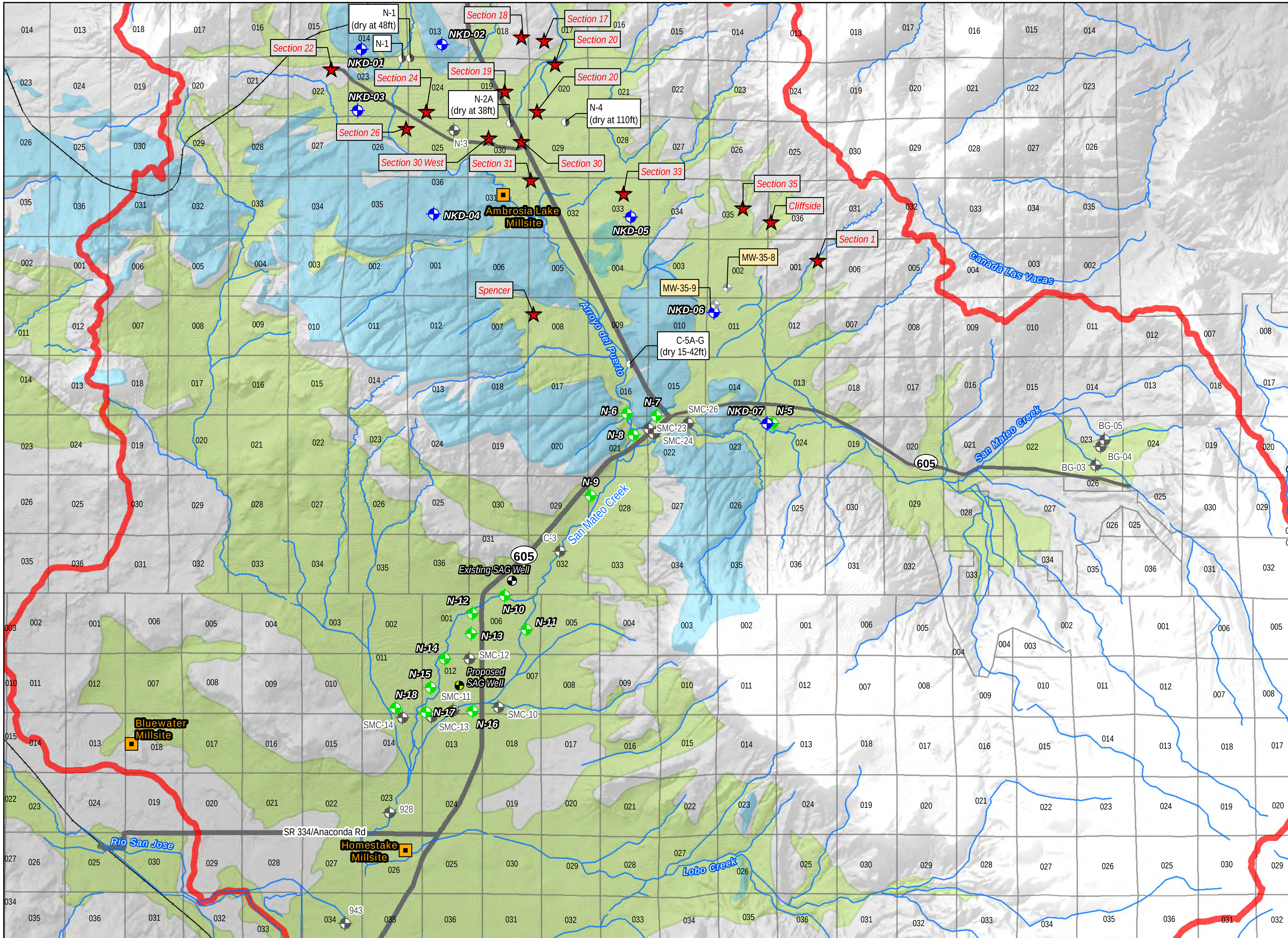
US EPA REGION 6

FIGURE 2-1
SITE AREA MAP
TRONOX MINE SITES
R6/R9
HWY 509 AND 605
CIBOLA & MCKINLEY COUNTIES,
NEW MEXICO

DATE	PROJECT NO	SCALE
APRIL, 2015	20406.012.019.0930.01	AS SHOWN

CERCLIS ID: NMN000606847
TDD NO: 19/WESTON-042-15-004
SOURCE: U.S. Geological Survey, 1:100000 Topographic Quadrangle, Chaco Mesa and Grants, New Mexico - 1997

FILE: L:\20406_START3_R6\TRONOX_MINE_ASSESSMENTS\GIS\Figure 2-1 Site Area Map.mxd 3:13:19 PM 5/28/2015 wilderj



New Mexico

LEGEND

- Millsite
- Tronox Mine Location
- Proposed Alluvial Monitor Well
- Proposed Dakota Sandstone Monitor Well
- Existing Monitoring Well
- Proposed SAG Well Location
- Existing SAG Well Location
- Dakota Sandstone
- Alluvium
- San Mateo Creek Basin
- Sections

NOTES:

"SAG" is San Andres - Glorieta Limestone

SMC-23, SMC-24, and SMC-26 are potential Alluvial and.or Dakota Sandstone wells.

SMC-10, SMC-11, SMC-12, SMC-13, and SMC-14 will not be sampled. These are on the map for location reference points.

N

0 0.75 1.5
Miles

CERCLIS ID: NMN000606847
TDD NO: 19/WESTON-042-15-004

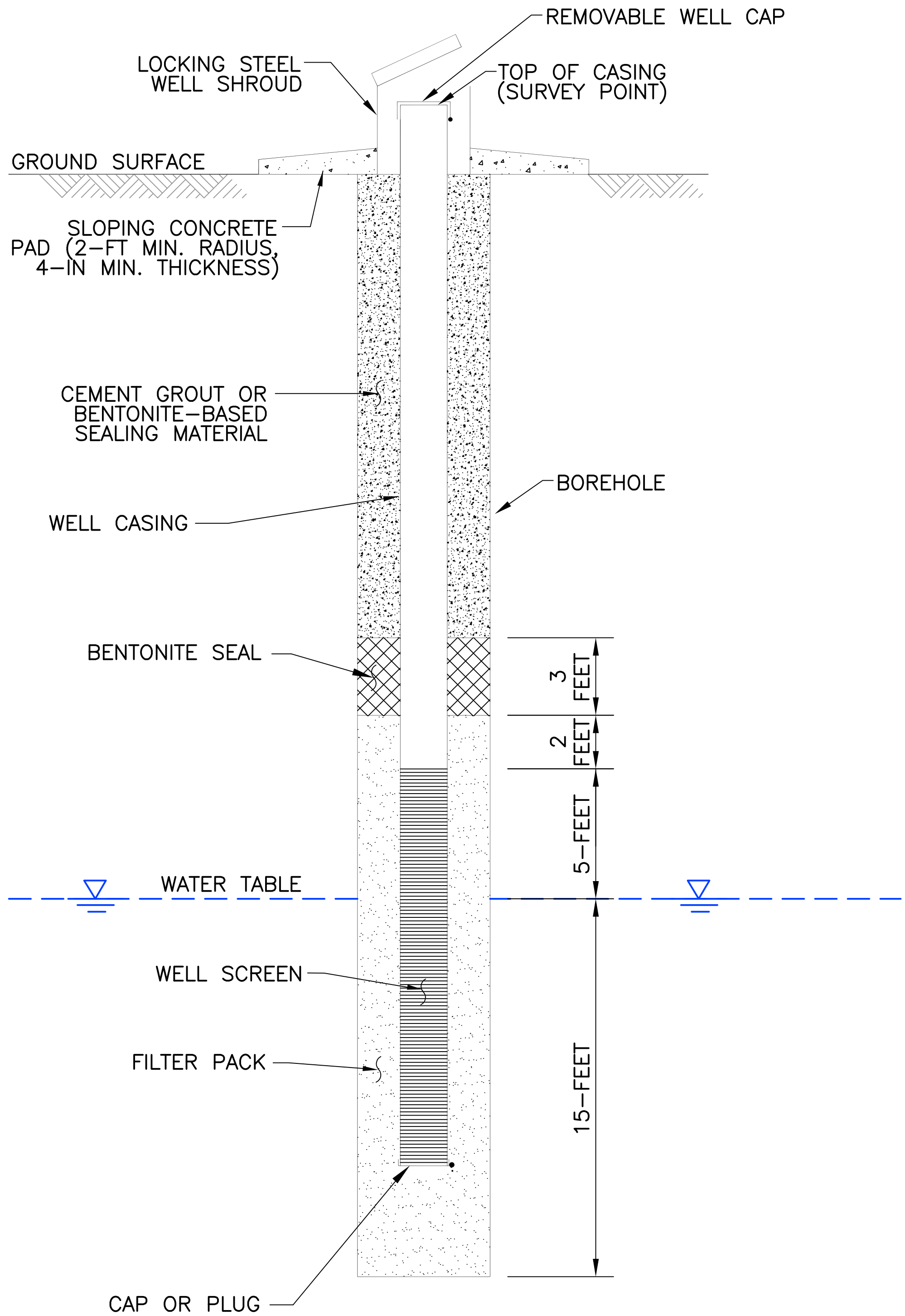
SOURCE:U.S. Geological Survey, National Elevation Dataset, 2010

USEPA REGION 6

FIGURE 3-1
PROPOSED SAMPLE LOCATION MAP
TRONOX MINE SITES
R6/R9
HWY 509 AND 605
CIBOLA & MCKINLEY COUNTIES,
NEW MEXICO

DATE	PROJECT NO	SCALE
APRIL, 2015	20406.012.019.0930.01	AS SHOWN

FILE: L:\20406_START3_R6\TRONOX_MINE_ASSESSMENTS\GIS\Rio Algom Sample Locations-11x17-Size_150513.mxd 1:38:46 PM 6/2/2015 wilderj



SOURCE: NEW MEXICO ENVIRONMENTAL DEPARTMENT
MONITORING WELL GUIDELINES REV. 1.1, MARCH 2011.
CERCLIS No.: NMN000606847
TDD No.: 19/WESTON-042-15-004

US EPA REGION 6

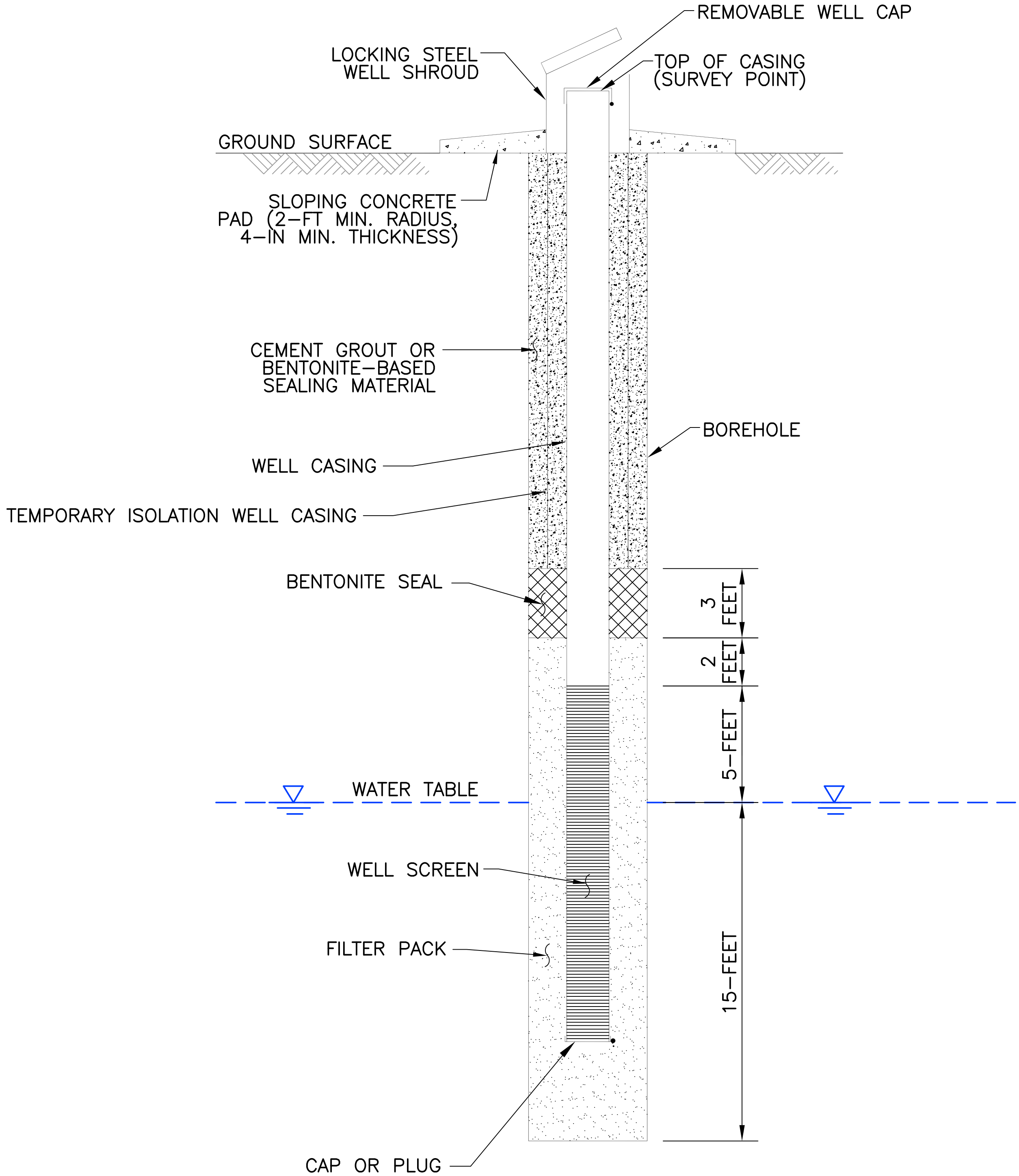
FIGURE 3-2

ALLUVIAL MONITORING WELL SCHEMATIC

TRONOX MINE SITES
R6/R9
CIBOLA & MCKINLEY COUNTIES, NEW MEXICO

DATE:	W.O. #	SCALE:
APR 2015	20406.012.019.0930.01	NOT TO SCALE

H:\START III EPA\4010_Tronox\Well Templates.dwg May 28, 2015 - 3:04pm



SOURCE: NEW MEXICO ENVIRONMENTAL DEPARTMENT MONITORING WELL GUIDELINES REV. 1.1, MARCH 2011.
CERCLIS No.: NMN000606847
TDD No.: 19/WESTON-042-15-004

US EPA REGION 6

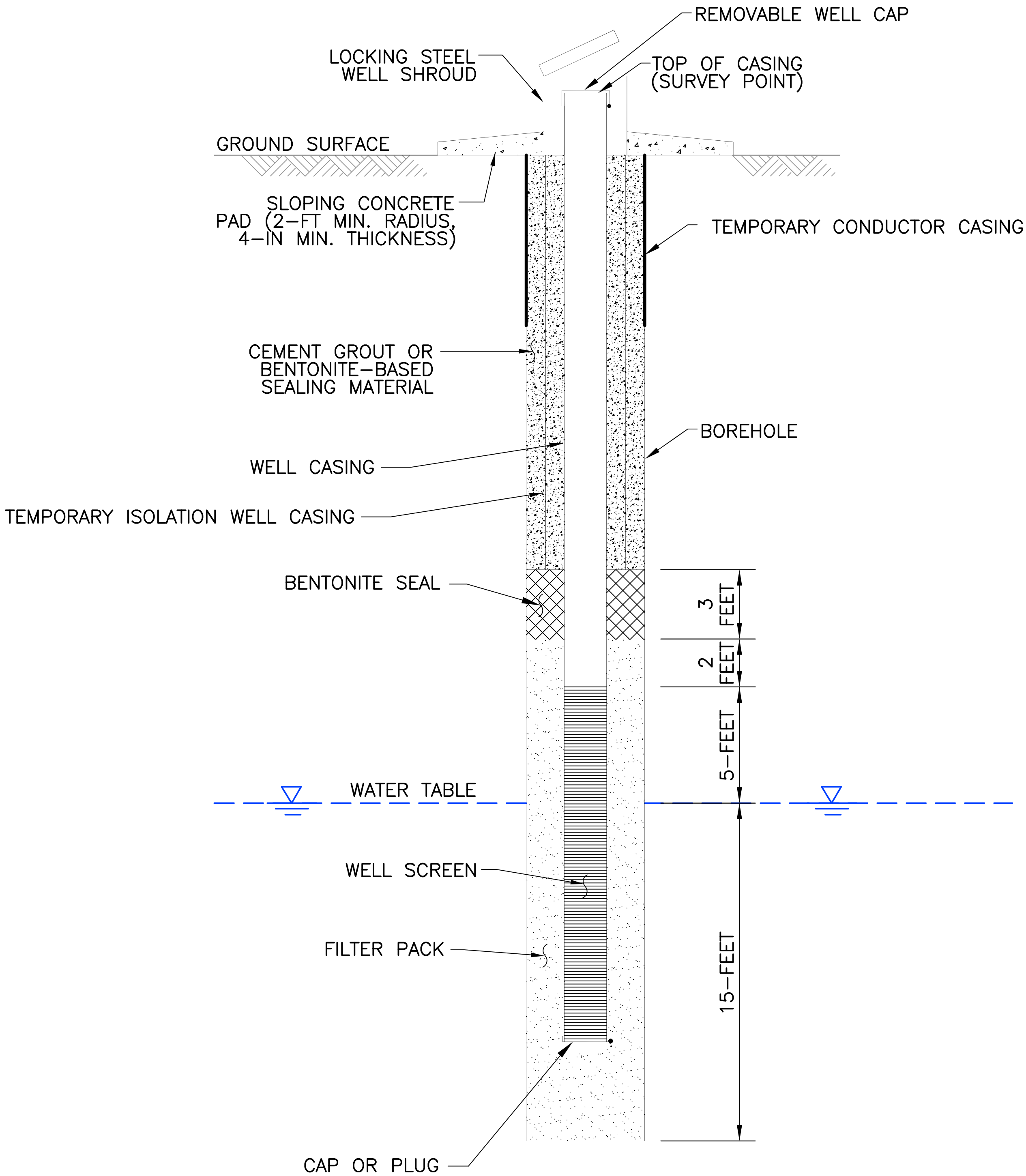
FIGURE 3-3

DAKOTA SANDSTONE MONITORING WELL SCHEMATIC

TRONOX MINE SITES
R6/R9
CIBOLA & MCKINLEY COUNTIES, NEW MEXICO

DATE:	W.O. #	SCALE:
APR 2015	20406.012.019.0930.01	NOT TO SCALE

H:\START III EPA\4010_Tronox\Well Templates.dwg May 28, 2015 - 3:04pm



SOURCE: NEW MEXICO ENVIRONMENTAL DEPARTMENT MONITORING WELL GUIDELINES REV. 1.1, MARCH 2011.
CERCLIS No.: NMN000606847
TDD No.: 19/WESTON-042-15-004

US EPA REGION 6

FIGURE 3-4

SAN ANDRES GLORIETTA MONITORING WELL SCHEMATIC

TRONOX MINE SITES
R6/R9
CIBOLA & MCKINLEY COUNTIES, NEW MEXICO

DATE:	W.O. #	SCALE:
APR 2015	20406.012.019.0930.01	NOT TO SCALE

H:\START III EPA\4010_Tronox\Well Templates.dwg May 28, 2015 - 3:04pm

APPENDIX A

EPA GUIDANCE FOR LOW-FLOW (MINIMAL DRAWDOWN) GROUNDWATER SAMPLING PROCEDURES

United States Environmental Protection Agency | Office of Research and Development | Office of Solid Waste and Emergency Response | EPA/540/S-95/504 April 1996

Ground Water Issue

LOW-FLOW (MINIMAL DRAWDOWN) GROUND-WATER SAMPLING PROCEDURES

by Robert W. Puls[1] and Michael J. Barcelona[2]

Background

The Regional Superfund Ground Water Forum is a group of ground-water scientists, representing EPA's Regional Superfund Offices, organized to exchange information related to ground-water remediation at Superfund sites. One of the major concerns of the Forum is the sampling of ground water to support site assessment and remedial performance monitoring objectives. This paper is intended to provide background information on the development of low-flow sampling procedures and its application under a variety of hydrogeologic settings. It is hoped that the paper will support the production of standard operating procedures for use by EPA Regional personnel and other environmental professionals engaged in ground-water sampling.

For further information contact: Robert Puls, 405-436-8543, Subsurface Remediation and Protection Division, NRMRL, Ada, Oklahoma.

I. Introduction

The methods and objectives of ground-water sampling to assess water quality have evolved over time. Initially the emphasis was on the assessment of water quality of aquifers as sources of drinking water. Large water-bearing units were identified and sampled in keeping with that objective. These were highly productive aquifers that supplied drinking water via private wells or through public water supply systems. Gradually, with the increasing awareness of subsurface pollution of these water resources, the understanding of complex hydrogeochemical processes which govern the fate and transport of contaminants in the subsurface increased. This increase in understanding was also due to advances in a number of scientific disciplines and improvements in tools used for site characterization and ground-water sampling. Ground-water quality investigations where pollution was detected initially borrowed ideas, methods, and materials for site characterization from the water supply field and water analysis from public health practices. This included the materials and manner in which monitoring wells were installed and the way in which water was brought to the surface, treated, preserved and analyzed. The prevailing conceptual ideas included convenient generalizations of ground-water resources in terms of large and relatively homogeneous hydrologic *units*. With time it became apparent that conventional water supply generalizations of *homogeneity* did not adequately represent field data regarding pollution of these subsurface resources. The important role of *heterogeneity* became increasingly clear not only in geologic terms, but also in terms of complex physical,

[1]National Risk Management Research Laboratory, U.S. EPA
[2]University of Michigan

Superfund Technology Support Center for Ground Water

National Risk Management Research Laboratory
Subsurface Protection and Remediation Division
Robert S. Kerr Environmental Research Center
Ada, Oklahoma

Technology Innovation Office
Office of Solid Waste and Emergency Response, US EPA, Washington, DC

Walter W. Kovalick, Jr., Ph.D.
Director

chemical and biological subsurface processes. With greater appreciation of the role of heterogeneity, it became evident that subsurface pollution was ubiquitous and encompassed the unsaturated zone to the deep subsurface and included unconsolidated sediments, fractured rock, and *aquitards* or low-yielding or impermeable formations. Small-scale processes and heterogeneities were shown to be important in identifying contaminant distributions and in controlling water and contaminant flow paths.

It is beyond the scope of this paper to summarize all the advances in the field of ground-water quality investigations and remediation, but two particular issues have bearing on ground-water sampling today: aquifer heterogeneity and colloidal transport. Aquifer heterogeneities affect contaminant flow paths and include variations in geology, geochemistry, hydrology and microbiology. As methods and the tools available for subsurface investigations have become increasingly sophisticated and understanding of the subsurface environment has advanced, there is an awareness that in most cases a primary concern for site investigations is characterization of contaminant flow paths rather than entire aquifers. In fact, in many cases, plume thickness can be less than well screen lengths (e.g., 3-6 m) typically installed at hazardous waste sites to detect and monitor plume movement over time. Small-scale differences have increasingly been shown to be important and there is a general trend toward smaller diameter wells and shorter screens.

The hydrogeochemical significance of colloidal-size particles in subsurface systems has been realized during the past several years (Gschwend and Reynolds, 1987; McCarthy and Zachara, 1989; Puls, 1990; Ryan and Gschwend, 1990). This realization resulted from both field and laboratory studies that showed faster contaminant migration over greater distances and at higher concentrations than flow and transport model predictions would suggest (Buddemeier and Hunt, 1988; Enfield and Bengtsson, 1988; Penrose et al., 1990). Such models typically account for interaction between the mobile aqueous and immobile solid phases, but do not allow for a mobile, reactive solid phase. It is recognition of this third *phase* as a possible means of contaminant transport that has brought increasing attention to the manner in which samples are collected and processed for analysis (Puls et al., 1990; McCarthy and Degueldre, 1993; Backhus et al., 1993; U. S. EPA, 1995). If such a phase is present in sufficient mass, possesses high sorption reactivity, large surface area, and remains stable in suspension, it can serve as an important mechanism to facilitate contaminant transport in many types of subsurface systems.

Colloids are particles that are sufficiently small so that the surface free energy of the particle dominates the bulk free energy. Typically, in ground water, this includes particles with diameters between 1 and 1000 nm. The most commonly observed mobile particles include: secondary clay minerals; hydrous iron, aluminum, and manganese oxides; dissolved and particulate organic materials, and viruses and bacteria. These reactive particles have been shown to be mobile under a variety of conditions in both field studies and laboratory column experiments, and as such need to be included in monitoring programs where identification of the *total* mobile contaminant loading (dissolved + naturally suspended particles) at a site is an objective. To that end, sampling methodologies must be used which do not artificially bias *naturally* suspended particle concentrations.

Currently the most common ground-water purging and sampling methodology is to purge a well using bailers or high speed pumps to remove 3 to 5 casing volumes followed by sample collection. This method can cause adverse impacts on sample quality through collection of samples with high levels of turbidity. This results in the inclusion of otherwise immobile artifactual particles which produce an overestimation of certain analytes of interest (e.g., metals or hydrophobic organic compounds). Numerous documented problems associated with filtration (Danielsson, 1982; Laxen and Chandler, 1982; Horowitz et al., 1992) make this an undesirable method of rectifying the turbidity problem, and include the removal of potentially mobile (contaminant-associated) particles during filtration, thus artificially biasing contaminant concentrations low. Sampling-induced turbidity problems can often be mitigated by using low-flow purging and sampling techniques.

Current subsurface conceptual models have undergone considerable refinement due to the recent development and increased use of field screening tools. So-called hydraulic *push* technologies (e.g., cone penetrometer, Geoprobe®, QED HydroPunch®) enable relatively fast screening site characterization which can then be used to design and install a monitoring well network. Indeed, alternatives to conventional monitoring wells are now being considered for some hydrogeologic settings. The ultimate design of any monitoring system should however be based upon adequate site characterization and be consistent with established monitoring objectives.

If the sampling program objectives include accurate assessment of the magnitude and extent of subsurface contamination over time and/or accurate assessment of subsequent remedial performance, then some information regarding plume delineation in three-dimensional space is necessary prior to monitoring well network design and installation. This can be accomplished with a variety of different tools and equipment ranging from hand-operated augers to screening tools mentioned above and large drilling rigs. Detailed information on ground-water flow velocity, direction, and horizontal and vertical variability are essential baseline data requirements. Detailed soil and geologic data are required prior to and during the installation of sampling points. This includes historical as well as detailed soil and geologic logs which accumulate during the site investigation. The use of borehole geophysical techniques is also recommended. With this information (together with other site characterization data) and a clear understanding of sampling objectives, then appropriate location, screen length, well diameter, slot size, etc. for the monitoring well network can be decided. This is especially critical for new in situ remedial approaches or natural attenuation assessments at hazardous waste sites.

In general, the overall goal of any ground-water sampling program is to collect water samples with no alteration in water chemistry; analytical data thus obtained may be used for a variety of specific monitoring programs depending on the regulatory requirements. The sampling methodology described in this paper assumes that the monitoring goal is to sample monitoring wells for the presence of contaminants and it is applicable whether mobile colloids are a concern or not and whether the analytes of concern are metals (and metalloids) or organic compounds.

II. Monitoring Objectives and Design Considerations

The following issues are important to consider prior to the design and implementation of any ground-water monitoring program, including those which anticipate using low-flow purging and sampling procedures.

A. Data Quality Objectives (DQOs)

Monitoring objectives include four main types: detection, assessment, corrective-action evaluation and resource evaluation, along with *hybrid* variations such as site-assessments for property transfers and water availability investigations. Monitoring objectives may change as contamination or water quality problems are discovered. However, there are a number of common components of monitoring programs which should be recognized as important regardless of initial objectives. These components include:

1) Development of a conceptual model that incorporates elements of the regional geology to the local geologic framework. The conceptual model development also includes initial site characterization efforts to identify hydrostratigraphic units and likely flow-paths using a minimum number of borings and well completions;

2) Cost-effective and well documented collection of high quality data utilizing simple, accurate, and reproducible techniques; and

3) Refinement of the conceptual model based on supplementary data collection and analysis.

These fundamental components serve many types of monitoring programs and provide a basis for future efforts that evolve in complexity and level of spatial detail as purposes and objectives expand. High quality, reproducible data collection is a common goal regardless of program objectives.

High quality data collection implies data of sufficient accuracy, precision, and completeness (i.e., ratio of valid analytical results to the minimum sample number called for by the program design) to meet the program objectives. Accuracy depends on the correct choice of monitoring tools and procedures to minimize sample and subsurface disturbance from collection to analysis. Precision depends on the repeatability of sampling and analytical protocols. It can be assured or improved by replication of sample analyses including blanks, field/lab standards and reference standards.

B. Sample Representativeness

An important goal of any monitoring program is collection of data that is truly representative of conditions at the site. The term *representativeness* applies to chemical and hydrogeologic data collected via wells, borings, piezometers, geophysical and soil gas measurements, lysimeters, and temporary sampling points. It involves a recognition of the statistical variability of individual subsurface physical properties, and contaminant or major ion concentration levels, while explaining extreme values. Subsurface temporal and spatial variability are facts. Good professional practice seeks to maximize representativeness by using proven accurate and reproducible techniques to define limits on the distribution of measurements collected at a site. However, measures of representativeness are dynamic and are controlled by evolving site characterization and monitoring objectives. An evolutionary site characterization model, as shown in Figure 1, provides a systematic approach to the goal of consistent data collection.

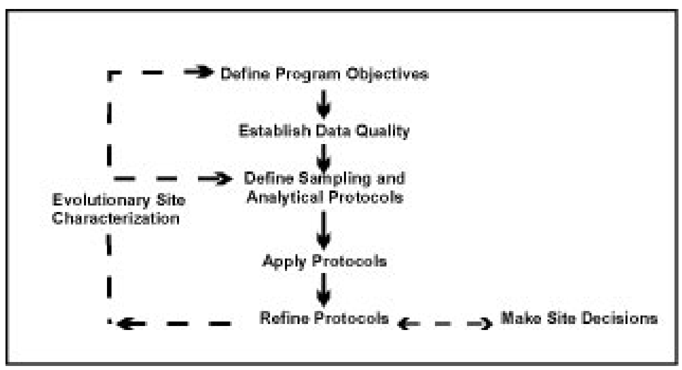


Figure 1. Evolutionary Site Characterization Model

The model emphasizes a recognition of the causes of the variability (e.g., use of inappropriate technology such as using bailers to purge wells; imprecise or operator-dependent methods) and the need to control avoidable errors.

1) Questions of Scale

A sampling plan designed to collect representative samples must take into account the potential scale of changes in site conditions through space and time as well as the chemical associations and behavior of the parameters that are targeted for investigation. In subsurface systems, physical (i.e., aquifer) and chemical properties over time or space are not statistically independent. In fact, samples taken in close proximity (i.e., within distances of a few meters) or within short time periods (i.e., more frequently than monthly) are highly auto-correlated. This means that designs employing high-sampling frequency (e.g., monthly) or dense spatial monitoring designs run the risk of redundant data collection and misleading inferences regarding trends in values that aren't statistically valid. In practice, contaminant detection and assessment monitoring programs rarely suffer these *over-sampling* concerns. In corrective-action evaluation programs, it is also possible that too little data may be collected over space or time. In these cases, false interpretation of the spatial extent of contamination or underestimation of temporal concentration variability may result.

2) Target Parameters

Parameter selection in monitoring program design is most often dictated by the regulatory status of the site. However, background water quality constituents, purging indicator parameters, and contaminants, all represent targets for data collection programs. The tools and procedures used in these programs should be equally rigorous and applicable to all categories of data, since all may be needed to determine or support regulatory action.

C. Sampling Point Design and Construction

Detailed site characterization is central to all decision-making purposes and the basis for this characterization resides in identification of the geologic framework and major hydro-stratigraphic units. Fundamental data for sample point location include: subsurface lithology, head-differences and background geochemical conditions. Each sampling point has a proper use or uses which should be documented at a level which is appropriate for the program's data quality objectives. Individual sampling points may not always be able to fulfill multiple monitoring objectives (e.g., detection, assessment, corrective action).

1) Compatibility with Monitoring Program and Data Quality Objectives

Specifics of sampling point location and design will be dictated by the complexity of subsurface lithology and variability in contaminant and/or geochemical conditions. It should be noted that, regardless of the ground-water sampling approach, few sampling points (e.g., wells, drive-points, screened augers) have zones of influence in excess of a few feet. Therefore, the spatial frequency of sampling points should be carefully selected and designed.

2) Flexibility of Sampling Point Design

In most cases *well-point* diameters in excess of 1 7/8 inches will permit the use of most types of submersible pumping devices for low-flow (minimal drawdown) sampling. It is suggested that *short* (e.g., less than 1.6 m) screens be incorporated into the monitoring design where possible so that comparable results from one device to another might be expected. *Short*, of course, is relative to the degree of vertical water quality variability expected at a site.

3) Equilibration of Sampling Point

Time should be allowed for equilibration of the well or sampling point with the formation after installation. Placement of well or sampling points in the subsurface produces some disturbance of ambient conditions. Drilling techniques (e.g., auger, rotary, etc.) are generally considered to cause more disturbance than *direct-push* technologies. In either case, there may be a period (i.e., days to months) during which water quality near the point may be distinctly different from that in the formation. Proper development of the sampling point and adjacent formation to remove fines created during emplacement will shorten this water quality *recovery* period.

III. Definition of Low-Flow Purging and Sampling

It is generally accepted that water in the well casing is non-representative of the formation water and needs to be purged prior to collection of ground-water samples. However, the water in the screened interval may indeed be representative of the formation, depending upon well construction and site hydrogeology. Wells are purged to some extent for the following reasons: the presence of the air interface at the top of the water column resulting in an oxygen concentration gradient with depth, loss of volatiles up the water column, leaching from or sorption to the casing or filter pack, chemical changes due to clay seals or backfill, and surface infiltration.

Low-flow purging, whether using portable or dedicated systems, should be done using pump-intake located in the middle or slightly above the middle of the screened interval. Placement of the pump too close to the bottom of the well will cause increased entrainment of solids which have collected in the well over time. These particles are present as a result of well development, prior purging and sampling events, and natural colloidal transport and deposition. Therefore, placement of the pump in the middle or toward the top of the screened interval is suggested. Placement of the pump at the top of the water column for sampling is only recommended in unconfined aquifers, screened across the water table, where this is the desired sampling point. Low-flow purging has the advantage of minimizing mixing between the overlying stagnant casing water and water within the screened interval.

A. Low-Flow Purging and Sampling

Low-flow refers to the velocity with which water enters the pump intake and that is imparted to the formation pore water in the immediate vicinity of the well screen. It does not necessarily refer to the flow rate of water discharged at the surface which can be affected by flow regulators or restrictions. Water level drawdown provides the best indication of the stress imparted by a given flow-rate for a given hydrological situation. The objective is to pump in a manner that minimizes stress (drawdown) to the system to the extent practical taking into account established site sampling objectives. Typically, flow rates on the order of 0.1 - 0.5 L/min are used, however this is dependent on site-specific hydrogeology. Some extremely coarse-textured formations have been successfully sampled in this manner at flow rates to 1 L/min. The effectiveness of using low-flow purging is intimately linked with proper screen location, screen length, and well construction and development techniques. The reestablishment of natural flow paths in both the vertical and horizontal directions is important for correct interpretation of the data. For high resolution sampling needs, screens less than 1 m should be used. Most of the need for purging has been found to be due to passing the sampling device through the overlying casing water which causes mixing of these stagnant waters and the dynamic waters within the screened interval. Additionally, there is disturbance to suspended sediment collected in the bottom of the casing and the displacement of water out into the formation immediately adjacent to the well screen. These disturbances and impacts can be avoided using dedicated sampling equipment, which precludes the need to insert the sampling device prior to purging and sampling.

Isolation of the screened interval water from the overlying stagnant casing water may be accomplished using low-flow minimal drawdown techniques. If the pump intake is located within the screened interval, most of the water pumped will be drawn in directly from the formation with little mixing of casing water or disturbance to the sampling zone. However, if the wells are not constructed and developed properly, zones other than those intended may be sampled. At some sites where geologic heterogeneities are sufficiently different within the screened interval, higher conductivity zones may be preferentially sampled. This is another reason to use shorter screened intervals, especially where high spatial resolution is a sampling objective.

B. Water Quality Indicator Parameters

It is recommended that water quality indicator parameters be used to determine purging needs prior to sample collection in each well. Stabilization of parameters such as pH, specific conductance, dissolved oxygen, oxidation-reduction potential, temperature and turbidity should be used to determine when formation water is accessed during purging. In general, the order of stabilization is pH, temperature, and specific conductance, followed by oxidation-reduction potential, dissolved oxygen and turbidity. Temperature and pH, while commonly used as purging indicators, are actually quite insensitive in distinguishing between formation water and stagnant casing water; nevertheless, these are important parameters for data interpretation purposes and should also be measured. Performance criteria for determination of stabilization should be based on water-level drawdown, pumping rate and equipment specifications for measuring indicator parameters. Instruments are available which utilize in-line flow cells to continuously measure the above parameters.

It is important to establish specific well stabilization criteria and then consistently follow the same methods thereafter, particularly with respect to drawdown, flow rate and sampling device. Generally, the time or purge volume required for parameter stabilization is independent of well depth or well volumes. Dependent variables are well diameter, sampling device, hydrogeochemistry, pump flow rate, and whether the devices are used in a portable or dedicated manner. If the sampling device is already in place (i.e., dedicated sampling systems), then the time and purge volume needed for stabilization is much shorter. Other advantages of dedicated equipment include less purge water for waste disposal, much less decontamination of equipment, less time spent in preparation of sampling as well as time in the field, and more consistency in the sampling approach which probably will translate into less variability in sampling results. The use of dedicated equipment is strongly recommended at wells which will undergo routine sampling over time.

If parameter stabilization criteria are too stringent, then minor oscillations in indicator parameters may cause purging operations to become unnecessarily protracted. It should also be noted that turbidity is a very conservative parameter in terms of stabilization. Turbidity is always the last parameter to stabilize. Excessive purge times are invariably related to the establishment of too stringent turbidity stabilization criteria. It should be noted that natural turbidity levels in ground water may exceed 10 nephelometric turbidity units (NTU).

C. Advantages and Disadvantages of Low-Flow (Minimum Drawdown) Purging

In general, the advantages of low-flow purging include:

- samples which are representative of the *mobile* load of contaminants present (dissolved and colloid-associated);
- minimal disturbance of the sampling point thereby minimizing sampling artifacts;
- less operator variability, greater operator control;

- reduced stress on the formation (minimal drawdown);
- less mixing of stagnant casing water with formation water;
- reduced need for filtration and, therefore, less time required for sampling;
- smaller purging volume which decreases waste disposal costs and sampling time;
- better sample consistency; reduced artificial sample variability.

Some disadvantages of low-flow purging are:
- higher initial capital costs,
- greater set-up time in the field,
- need to transport additional equipment to and from the site,
- increased training needs,
- resistance to change on the part of sampling practitioners,
- concern that new data will indicate a *change in conditions* and trigger an *action*.

IV. Low-Flow (Minimal Drawdown) Sampling Protocols

The following ground-water sampling procedure has evolved over many years of experience in ground-water sampling for organic and inorganic compound determinations and as such summarizes the authors' (and others) experiences to date (Barcelona et al., 1984, 1994; Barcelona and Helfrich, 1986; Puls and Barcelona, 1989; Puls et. al. 1990, 1992; Puls and Powell, 1992; Puls and Paul, 1995). High-quality chemical data collection is essential in ground-water monitoring and site characterization. The primary limitations to the collection of *representative* ground-water samples include: mixing of the stagnant casing and *fresh* screen waters during insertion of the sampling device or ground-water level measurement device; disturbance and resuspension of settled solids at the bottom of the well when using high pumping rates or raising and lowering a pump or bailer; introduction of atmospheric gases or degassing from the water during sample handling and transfer, or inappropriate use of vacuum sampling device, etc.

A. Sampling Recommendations

Water samples should not be taken immediately following well development. Sufficient time should be allowed for the ground-water flow regime in the vicinity of the monitoring well to stabilize and to approach chemical equilibrium with the well construction materials. This lag time will depend on site conditions and methods of installation but often exceeds one week.

Well purging is nearly always necessary to obtain samples of water flowing through the geologic formations in the screened interval. Rather than using a general but arbitrary guideline of purging three casing volumes prior to sampling, it is recommended that an in-line water quality measurement device (e.g., flow-through cell) be used to establish the stabilization time for several parameters (e.g. , pH, specific conductance, redox, dissolved oxygen, turbidity) on a well-specific basis. Data on pumping rate, drawdown, and volume required for parameter stabilization can be used as a guide for conducting subsequent sampling activities.

The following are recommendations to be considered before, during and after sampling:
- use low-flow rates (<0.5 L/min), during both purging and sampling to maintain minimal drawdown in the well;
- maximize tubing wall thickness, minimize tubing length;
- place the sampling device intake at the desired sampling point;
- minimize disturbances of the stagnant water column above the screened interval during water level measurement and sampling device insertion;
- make proper adjustments to stabilize the flow rate as soon as possible;
- monitor water quality indicators during purging;
- collect unfiltered samples to estimate contaminant loading and transport potential in the subsurface system.

B. Equipment Calibration

Prior to sampling, all sampling device and monitoring equipment should be calibrated according to manufacturer's recommendations and the site Quality Assurance Project Plan (QAPP) and Field Sampling Plan (FSP). Calibration of pH should be performed with at least two buffers which bracket the expected range. Dissolved oxygen calibration must be corrected for local barometric pressure readings and elevation.

C. Water Level Measurement and Monitoring

It is recommended that a device be used which will least disturb the water surface in the casing. Well depth should be obtained from the well logs. Measuring to the bottom of the well casing will only cause resuspension of settled solids from the formation and require longer purging times for turbidity equilibration. Measure well depth after sampling is completed. The water level measurement should be taken from a permanent reference point which is surveyed relative to ground elevation.

D. Pump Type

The use of low-flow (e.g., 0.1-0.5 L/min) pumps is suggested for purging and sampling all types of analytes. All pumps have some limitation and these should be investigated with respect to application at a particular site. Bailers are inappropriate devices for low-flow sampling.

1) General Considerations

There are no unusual requirements for ground-water sampling devices when using low-flow, minimal drawdown techniques. The major concern is that the device give consistent results and minimal disturbance of the sample across a range of *low* flow rates (i.e., < 0.5 L/min). Clearly, pumping rates that cause minimal to no drawdown in one well could easily cause *significant* drawdown in another well finished in a less transmissive formation. In this sense, the pump should not cause undue pressure or temperature changes or physical disturbance on the water sample over a reasonable sampling range. Consistency in operation is critical to meet accuracy and precision goals.

2) Advantages and Disadvantages of Sampling Devices

A variety of sampling devices are available for low-flow (minimal drawdown) purging and sampling and include peristaltic pumps, bladder pumps, electrical submersible pumps, and gas-driven pumps. Devices which lend themselves to both dedication and consistent operation at definable low-flow rates are preferred. It is desirable that the pump be easily adjustable and operate reliably at these lower flow rates. The peristaltic pump is limited to shallow applications and can cause degassing resulting in alteration of pH, alkalinity, and some volatiles loss. Gas-driven pumps should be of a type that does not allow the gas to be in direct contact with the sampled fluid.

Clearly, bailers and other *grab* type samplers are ill-suited for low-flow sampling since they will cause repeated disturbance and mixing of *stagnant* water in the casing and the *dynamic* water in the screened interval. Similarly, the use of inertial lift foot-valve type samplers may cause too much disturbance at the point of sampling. Use of these devices also tends to introduce uncontrolled and unacceptable operator variability.

Summaries of advantages and disadvantages of various sampling devices are listed in Herzog et al. (1991), U. S. EPA (1992), Parker (1994) and Thurnblad (1994).

E. Pump Installation

Dedicated sampling devices (left in the well) capable of pumping and sampling are preferred over <u>any</u> other type of device. Any portable sampling device should be slowly and carefully lowered to the middle of the screened interval or slightly above the middle (e.g., 1-1.5 m below the top of a 3 m screen). This is to minimize excessive mixing of the stagnant water in the casing above the screen with the screened interval zone water, and to minimize resuspension of solids which will have collected at the bottom of the well. These two disturbance effects have been shown to directly affect the time required for purging. There also appears to be a direct correlation between size of portable sampling devices relative to the well bore and resulting purge volumes and times. The key is to minimize disturbance of water and solids in the well casing.

F. Filtration

Decisions to filter samples should be dictated by sampling objectives rather than as a *fix* for poor sampling practices, and field-filtering of certain constituents should not be the default. Consideration should be given as to what the application of field-filtration is trying to accomplish. For assessment of truly dissolved (as opposed to operationally *dissolved* [i.e., samples filtered with 0.45 µm filters]) concentrations of major ions and trace metals, 0.1 µm filters are recommended although 0.45 µm filters are normally used for most regulatory programs. Alkalinity samples must also be filtered if significant particulate calcium carbonate is suspected, since this material is likely to impact alkalinity titration results (although filtration itself may alter the CO_2 composition of the sample and, therefore, affect the results).

Although filtration may be appropriate, filtration of a sample may cause a number of unintended changes to occur (e.g. oxidation, aeration) possibly leading to filtration-induced artifacts during sample analysis and uncertainty in the results. Some of these unintended changes may be unavoidable but the factors leading to them must be recognized. Deleterious effects can be minimized by consistent application of certain filtration guidelines. Guidelines should address selection of filter type, media, pore size, etc. in order to identify and minimize potential sources of uncertainty when filtering samples.

In-line filtration is recommended because it provides better consistency through less sample handling, and minimizes sample exposure to the atmosphere. In-line filters are available in both disposable (barrel filters) and non-disposable (in-line filter holder, flat membrane filters) formats and various filter pore sizes (0.1-5.0 µm). Disposable filter cartridges have the advantage of greater sediment handling capacity when compared to traditional membrane filters. Filters must be pre-rinsed following manufacturer's recommendations. If there are no recommendations for rinsing, pass through a minimum of 1 L of ground water following purging and prior to sampling. Once filtration has begun, a filter cake may develop as particles larger than the pore size accumulate on the filter membrane. The result is that the effective pore diameter of the membrane is reduced and particles smaller than the stated pore size are excluded from the filtrate. Possible corrective measures include prefiltering (with larger pore size filters), minimizing particle loads to begin with, and reducing sample volume.

G. Monitoring of Water Level and Water Quality Indicator Parameters

Check water level periodically to monitor drawdown in the well as a guide to flow rate adjustment. The goal is minimal drawdown (<0.1 m) during purging. This goal may be difficult to achieve under some circumstances due to geologic heterogeneities within the screened interval, and may require adjustment based on site-specific conditions and personal experience. In-line water quality indicator parameters should be continuously monitored during purging. The water quality indicator parameters monitored can include pH, redox potential, conductivity, dissolved oxygen (DO) and turbidity. The last three parameters are often most sensitive. Pumping rate, drawdown, and the time or volume required to obtain stabilization of parameter readings can be used as a future guide to purge the well. Measurements should be taken every three to five minutes if the above suggested rates are used. Stabilization is achieved after all parameters have stabilized for three successive readings. In lieu of measuring all five parameters, a minimum subset would include pH, conductivity, and turbidity or DO. Three successive readings should be within ± 0.1 for pH, ± 3% for conductivity, ± 10 mv for redox potential, and ± 10% for turbidity and DO. Stabilized purge indicator parameter trends are generally obvious and follow either an exponential or asymptotic change to stable values during purging. Dissolved oxygen and turbidity usually require the longest time for stabilization. The above stabilization guidelines are provided for rough estimates based on experience.

H. Sampling, Sample Containers, Preservation and Decontamination

Upon parameter stabilization, sampling can be initiated. If an in-line device is used to monitor water quality parameters, it should be disconnected or bypassed during sample collection. Sampling flow rate may remain at established purge rate or may be adjusted slightly to minimize aeration, bubble formation, turbulent filling of sample bottles, or loss of volatiles due to extended residence time in tubing. Typically, flow rates less than 0.5 L/min are appropriate. The same device should be used for sampling as was used for purging. Sampling should occur in a progression from least to most contaminated well, if this is known. Generally, volatile (e.g., solvents and fuel constituents) and gas sensitive (e.g., Fe^{2+}, CH_4, H_2S/HS^-, alkalinity) parameters should be sampled first. The sequence in which samples for most inorganic parameters are collected is immaterial unless filtered (dissolved) samples are desired. Filtering should be done last and in-line filters should be used as discussed above. During both well purging and sampling, proper protective clothing and equipment must be used based upon the type and level of contaminants present.

The appropriate sample container will be prepared in advance of actual sample collection for the analytes of interest and include sample preservative where necessary. Water samples should be collected directly into this container from the pump tubing.

Immediately after a sample bottle has been filled, it must be preserved as specified in the site (QAPP). Sample preservation requirements are based on the analyses being performed (use site QAPP, FSP, RCRA guidance document [U. S. EPA, 1992] or EPA SW-846 [U. S. EPA, 1982]). It may be advisable to add preservatives to sample bottles in a controlled setting prior to entering the field in order to reduce the chances of improperly preserving sample bottles or introducing field contaminants into a sample bottle while adding the preservatives.

The preservatives should be transferred from the chemical bottle to the sample container using a disposable polyethylene pipet and the disposable pipet should be used only once and then discarded.

After a sample container has been filled with ground water, a Teflon™ (or tin)-lined cap is screwed on tightly to prevent the container from leaking. A sample label is filled out as specified in the FSP. The samples should be stored inverted at 4°C.

Specific decontamination protocols for sampling devices are dependent to some extent on the type of device used and the type of contaminants encountered. Refer to the site QAPP and FSP for specific requirements.

I. Blanks

The following blanks should be collected:

(1) field blank: one field blank should be collected from each source water (distilled/deionized water) used for sampling equipment decontamination or for assisting well development procedures.

(2) equipment blank: one equipment blank should be taken prior to the commencement of field work, from each set of sampling equipment to be used for that day. Refer to site QAPP or FSP for specific requirements.

(3) trip blank: a trip blank is required to accompany each volatile sample shipment. These blanks are prepared in the laboratory by filling a 40-mL volatile organic analysis (VOA) bottle with distilled/deionized water.

V. Low-Permeability Formations and Fractured Rock

The overall sampling program goals or sampling objectives will drive how the sampling points are located, installed, and choice of sampling device. Likewise, site-specific hydrogeologic factors will affect these decisions. Sites with very low permeability formations or fractures causing discrete flow channels may require a unique monitoring approach. Unlike water supply wells, wells installed for ground-water quality assessment and restoration programs are often installed in low water-yielding settings (e.g., clays, silts). Alternative types of sampling points and sampling methods are often needed in these types of environments, because low-permeability settings may require extremely low-flow purging (<0.1 L/min) and may be technology-limited. Where devices are not readily available to pump at such low flow rates, the primary consideration is to avoid dewatering of the well screen. This may require repeated recovery of the water during purging while leaving the pump in place within the well screen.

Use of low-flow techniques may be impractical in these settings, depending upon the water recharge rates. The sampler and the end-user of data collected from such wells need to understand the limitations of the data collected; i.e., a strong potential for underestimation of actual contaminant concentrations for volatile organics, potential false negatives for filtered metals and potential false positives for unfiltered metals. It is suggested that comparisons be made between samples recovered using low-flow purging techniques and samples recovered using passive sampling techniques (i.e., two sets of samples). Passive sample collection would essentially entail acquisition of the sample with no or very little purging using a dedicated sampling system installed within the screened interval or a passive sample collection device.

A. Low-Permeability Formations (<0.1 L/min recharge)

1. Low-Flow Purging and Sampling with Pumps

a. “portable or non-dedicated mode” - Lower the pump (one capable of pumping at <0.1 L/min) to mid-screen or slightly above and set in place for minimum of 48 hours (to lessen purge volume requirements). After 48 hours, use procedures listed in Part IV above regarding monitoring water quality parameters for stabilization, etc., but do not dewater the screen. If excessive drawdown and slow recovery is a problem, then alternate approaches such as those listed below may be better.

b. “dedicated mode” - Set the pump as above at least a week prior to sampling; that is, operate in a dedicated pump mode. With this approach significant reductions in purge volume should be realized. Water quality parameters should stabilize quite rapidly due to less disturbance of the sampling zone.

2. Passive Sample Collection

Passive sampling collection requires insertion of the device into the screened interval for a sufficient time period to allow flow and sample equilibration before extraction for analysis. Conceptually, the extraction of water from low yielding formations seems more akin to the collection of water from the unsaturated zone and passive sampling techniques may be more appropriate in terms of obtaining “representative” samples. Satisfying usual sample volume requirements is typically a problem with this approach and some latitude will be needed on the part of regulatory entities to achieve sampling objectives.

B. Fractured Rock

In fractured rock formations, a low-flow to zero purging approach using pumps in conjunction with packers to isolate the sampling zone in the borehole is suggested. Passive multi-layer sampling devices may also provide the most “representative” samples. It is imperative in these settings to identify flow paths or water-producing fractures prior to sampling using tools such as borehole flowmeters and/or other geophysical tools.

After identification of water-bearing fractures, install packer(s) and pump assembly for sample collection using low-flow sampling in “dedicated mode” or use a passive sampling device which can isolate the identified water-bearing fractures.

VI. Documentation

The usual practices for documenting the sampling event should be used for low-flow purging and sampling techniques. This should include, at a minimum: information on the conduct of purging operations (flow-rate, drawdown, water-quality parameter values, volumes extracted and times for measurements), field instrument calibration data, water sampling forms and chain of custody forms. See Figures 2 and 3 and “Ground Water Sampling Workshop -- A Workshop Summary” (U. S. EPA, 1995) for example forms and other documentation suggestions and information. This information coupled with laboratory analytical data and validation data are needed to judge the “useability” of the sampling data.

VII. Notice

The U.S. Environmental Protection Agency through its Office of Research and Development funded and managed the research described herein as part of its in-house research program and under Contract No. 68-C4-0031 to Dynamac Corporation. It has been subjected to the Agency's peer and administrative review and has been approved for publication as an EPA document. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

VIII. References

Backhus, D,A., J.N. Ryan, D.M. Groher, J.K. McFarlane, and P.M. Gschwend. 1993. Sampling Colloids and Colloid-Associated Contaminants in Ground Water. *Ground Water*, 31(3):466-479.

Barcelona, M.J., J.A. Helfrich, E.E. Garske, and J.P. Gibb. 1984. A laboratory evaluation of groundwater sampling mechanisms. *Ground Water Monitoring Review*, 4(2):32-41.

Barcelona, M.J. and J.A. Helfrich. 1986. Well construction and purging effects on ground-water samples. *Environ. Sci. Technol.,* 20(11):1179-1184.

Barcelona, M.J., H.A. Wehrmann, and M.D. Varljen. 1994. Reproducible well purging procedures and VOC stabilization criteria for ground-water sampling. *Ground Water*, 32(1):12-22.

Buddemeier, R.W. and J.R. Hunt. 1988. Transport of Colloidal Contaminants in Ground Water: Radionuclide Migration at the Nevada Test Site. *Applied Geochemistry*, 3: 535-548.

Danielsson, L.G. 1982. On the Use of Filters for Distinguishing Between Dissolved and Particulate Fractions in Natural Waters. *Water Research*, 16:179.

Enfield, C.G. and G. Bengtsson. 1988. Macromolecular Transport of Hydrophobic Contaminants in Aqueous Environments. *Ground Water,* 26(1): 64-70.

Gschwend, P.M. and M.D. Reynolds. 1987. Monodisperse Ferrous Phosphate Colloids in an Anoxic Groundwater Plume, *J. of Contaminant Hydrol.,* 1: 309-327.

Herzog, B., J. Pennino, and G. Nielsen. 1991. Ground-Water Sampling. In **Practical Handbook of Ground-Water Monitoring** (D.M. Nielsen, ed.). Lewis Publ., Chelsea, MI, pp. 449-499.

Horowitz, A.J., K.A. Elrick, and M.R. Colberg. 1992. The effect of membrane filtration artifacts on dissolved trace element concentrations. *Water Res.,* 26(6):753-763.

Laxen, D.P.H. and I.M. Chandler. 1982. Comparison of Filtration Techniques for Size Distribution in Freshwaters. *Analytical Chemistry*, 54(8):1350.

McCarthy, J.F. and J.M. Zachara. 1989. Subsurface Transport of Contaminants, *Environ. Sci. Technol.*, 5(23):496-502.

McCarthy, J.F. and C. Degueldre. 1993. Sampling and Characterization of Colloids and Ground Water for Studying Their Role in Contaminant Transport. In: Environmental Particles (J. Buffle and H.P. van Leeuwen, eds.), Lewis Publ., Chelsea, MI, pp. 247-315.

Parker, L.V. 1994. The Effects of Ground Water Sampling Devices on Water Quality: A Literature Review. *Ground Water Monitoring and Remediation*, 14(2):130-141.

Penrose, W.R., W.L. Polzer, E.H. Essington, D.M. Nelson, and K.A. Orlandini. 1990. Mobility of Plutonium and Americium through a Shallow Aquifer in a Semiarid Region, *Environ. Sci. Technol.*, 24:228-234.

Puls, R.W. and M.J. Barcelona. 1989. Filtration of Ground Water Samples for Metals Analyses. *Hazardous Waste and Hazardous Materials,* 6(4):385-393.

Puls, R.W., J.H. Eychaner, and R.M. Powell. 1990. Colloidal-Facilitated Transport of Inorganic Contaminants in Ground Water: Part I. Sampling Considerations. EPA/600/M-90/023, NTIS PB 91-168419.

Puls, R.W. 1990. Colloidal Considerations in Groundwater Sampling and Contaminant Transport Predictions. *Nuclear Safety*, 31(1):58-65.

Puls, R.W. and R.M. Powell. 1992. Acquisition of Representative Ground Water Quality Samples for Metals. *Ground Water Monitoring Review,* 12(3):167-176.

Puls, R.W., D.A. Clark, B.Bledsoe, R.M. Powell, and C.J. Paul. 1992. Metals in Ground Water: Sampling Artifacts and Reproducibility. *Hazardous Waste and Hazardous Materials*, 9(2): 149-162.

Puls, R.W. and C.J. Paul. 1995. Low-Flow Purging and Sampling of Ground-Water Monitoring Wells with Dedicated Systems. *Ground Water Monitoring and Remediation,* 15(1):116-123.

Ryan, J.N. and P.M. Gschwend. 1990. Colloid Mobilization in Two Atlantic Coastal Plain Aquifers. *Water Resour. Res.*, 26: 307-322.

Thurnblad, T. 1994. Ground Water Sampling Guidance: Development of Sampling Plans, Sampling Protocols, and Sampling Reports. Minnesota Pollution Control Agency.

U. S. EPA. 1992. RCRA Ground-Water Monitoring: Draft Technical Guidance. Office of Solid Waste, Washington, DC EPA/530/R-93/001, NTIS PB 93-139350.

U. S. EPA. 1995. Ground Water Sampling Workshop -- A Workshop Summary, Dallas, TX, November 30 - December 2, 1993. EPA/600/R-94/205, NTIS PB 95-193249, 126 pp.

U. S. EPA. 1982. Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, EPA SW-846. Office of Solid Waste and Emergency Response, Washington, D.C.

Figure 2. **Ground Water Sampling Log**

Project _______________ **Site** _______________ **Well No.** _____________ **Date** _________________________

Well Depth ____________ **Screen Length** __________ **Well Diameter** _________ **Casing Type** ____________

Sampling Device _______________ **Tubing type** _____________________ **Water Level** __________________

Measuring Point ___________________ **Other Infor** ____

____

Sampling Personnel ____

Time	pH	Temp	Cond.	Dis.O_2	Turb.	[ ]Conc			Notes

Type of Samples Collected

____

Information: 2 in = 617 ml/ft, 4 in = 2470 ml/ft: $Vol_{cyl} = \pi r^2 h$, $Vol_{sphere} = 4/3\pi\ r^3$

Figure 3. **Ground Water Sampling Log** (with automatic data logging for most water quality parameters)

Project _______________ **Site** _______________ **Well No.** _____________ **Date** ________________________

Well Depth ____________ **Screen Length** __________ **Well Diameter** _________ **Casing Type** ___________

Sampling Device _______________ **Tubing type** _____________________ **Water Level** _________________

Measuring Point ___________________ **Other Infor** ____

____

Sampling Personnel ____

Time	Pump Rate	Turbidity	Alkalinity	[ ] Conc	Notes

Type of Samples Collected

____

Information: 2 in = 617 ml/ft, 4 in = 2470 ml/ft: $Vol_{cyl} = \pi r^2 h$, $Vol_{sphere} = 4/3\pi\ r^3$

APPENDIX B

STANDARD OPERATING PROCEDURES (SOPs)

(b) (4)

[redacted]

(b) (4)

[redacted]

(b) (4)

[redacted]

(b) (4)

[redacted]

(b) (4)

[redacted]

(b) (4)

[redacted]

(b) (4)

[redacted]

(b) (4)

[redacted]

(b) (4)

[redacted]

(b) (4)

[redacted]

(b) (4)

[redacted]

(b) (4)

[redacted]

(b) (4)

[redacted]

(b) (4)

[redacted]

(b) (4)

[redacted]

(b) (4)

[redacted]

(b) (4)

[redacted]

(b) (4)

[redacted]

(b) (4)

[redacted]

(b) (4)

[redacted]

(b) (4)

[redacted]

(b) (4)

[redacted]

(b) (4)

[redacted]

(b) (4)

[redacted]

(b) (4)

[redacted]

(b) (4)

[redacted]

(b) (4)

[redacted]

(b) (4)

[redacted]

(b) (4)

[redacted]

(b) (4)
[redacted]

(b) (4)

[redacted]

(b) (4)

[redacted]

(b) (4)

[redacted]

(b) (4)

[redacted]

(b) (4)

[redacted]

(b) (4)

[redacted]

(b) (4)

[redacted]

(b) (4)

[redacted]

(b) (4)

[redacted]

(b) (4)

[redacted]

(b) (4)

[redacted]

(b) (4)

[redacted]

(b) (4)

[redacted]

(b) (4)

[redacted]

(b) (4)

[redacted]

(b) (4)

[redacted]

(b) (4)

[redacted]

(b) (4)

[redacted]

(b) (4)

[redacted]

APPENDIX C

SITE-SPECIFIC DATA QUALITY OBJECTIVE

APPENDIX C
DATA QUALITY OBJECTIVE – GROUNDWATER SAMPLING

STEP 1. STATE THE PROBLEM	
Historical surface and underground mining operations contributed waste (uranium and other metals/radionuclides) to natural surface drainage systems and groundwater within the San Mateo Creek Basin. This is potentially representing a threat to human health and the environment.	
STEP 2. IDENTIFY THE DECISION	
What are the concentrations of contaminants of concern (COCs) in groundwater, represented by a sample, above specified EPA Maximum Contaminant Levels (MCLs)?	
IDENTIFY THE ALTERNATIVE ACTIONS THAT MAY BE TAKEN BASED ON THE DECISIONS.	• If any COCs exceed the specified MCL in groundwater, the groundwater represented by that sample will be considered contaminated and will require additional attention. • If no contaminants exceed the specified MCL in groundwater, the groundwater represented by that sample will not require additional attention.
STEP 3. IDENTIFY INPUTS TO THE DECISION	
IDENTIFY THE INFORMATIONAL INPUTS NEEDED TO RESOLVE A DECISION.	• Groundwater information obtained from analytical results from groundwater samples collected during investigation.
IDENTIFY THE SOURCES FOR EACH INFORMATIONAL INPUT AND LIST THE INPUTS THAT ARE OBTAINED THROUGH ENVIRONMENTAL MEASUREMENTS.	• Sampling of groundwater at specific locations in the San Mateo Basin. See Figure 3-1 of the QASP. • Data will be obtained from samples collected as outlined in Table 3-1 and analyzed as presented in Table 4-1 of the QASP.
BASIS FOR THE CONTAMINANT-SPECIFIC ACTION LEVELS.	• Published EPA MCLs.
IDENTIFY POTENTIAL SAMPLING TECHNIQUES AND APPROPRIATE ANALYTICAL METHODS.	• Groundwater sampling techniques are described in the QASP. • Analytical methods are outlined in Table 4-1 of the QASP.

APPENDIX C
DATA QUALITY OBJECTIVE – GROUNDWATER SAMPLING (CONTINUED)

STEP 4. DEFINE THE BOUNDARIES OF THE STUDY	
DEFINE THE DOMAIN OR GEOGRAPHIC AREA WITHIN WHICH ALL DECISIONS MUST APPLY.	• The boundaries for the groundwater investigation are shown on Figure 3-1.
SPECIFY THE CHARACTERISTICS THAT DEFINE THE POPULATION OF INTEREST.	• Specific locations in the San Mateo Drainage basin.
DEFINE THE SCALE OF DECISION MAKING.	• The scale of decision will be for groundwater represented by each sample collected from the site.
DETERMINE THE TIME FRAME TO WHICH THE DATA APPLY.	• The data will apply until the site activities are complete.
DETERMINE WHEN TO COLLECT DATA.	• Samples will be collected during the field effort scheduled for mid-June 2015.
IDENTIFY PRACTICAL CONSTRAINTS ON DATA COLLECTION.	• Inclement weather. • Site access not attainable.
STEP 5. DEVELOP A DECISION RULE	
SPECIFY THE PARAMETER THAT CHARACTERIZES THE POPULATION OF INTEREST.	• The groundwater data and sample concentrations at each sample location within the San Mateo Drainage Basin.
SPECIFY THE ACTION LEVEL FOR THE DECISION.	• Published EPA MCLs.
DEVELOP A DECISION RULE.	• If any result in a groundwater sample is above the MCL, then the groundwater represented by that sample will require additional attention; otherwise, the groundwater does not require additional attention. • If no contaminants exceed the specified MCL in groundwater, the groundwater represented by that sample will not require additional attention.
STEP 6. SPECIFY LIMITS ON DECISION	
DETERMINE THE POSSIBLE RANGE OF THE PARAMETER OF INTEREST.	• Contaminant concentrations may range from 0 mg/L to greater than the MCL.
STEP 7. OPTIMIZE THE DESIGN	
REVIEW THE DQOS	• The sample size was based on groundwater sample locations within the San Mateo Creek Basin.
DEVELOP GENERAL SAMPLING AND ANALYSIS DESIGN. The EPA Team will collect groundwater samples from 22 newly installed monitor wells and 14 existing monitor wells from locations within the San Mateo Basin. Analytical data will be reviewed and compared to EPA MCLs. The groundwater samples will be collected as outlined in Section 3.0 of the QASP. Specific analytical parameters are listed in Table 4-1 of the QASP.	

APPENDIX D

INVESTIGATION-DERIVED WASTE MANAGEMENT PLAN

APPENDIX D

Investigation-derived Waste Management Plan
Tronox Mine Sites R6/R9
Cibola and McKinley Counties, New Mexico

1 INVESTIGATION-DERIVED WASTES

This appendix presents the steps that will be utilized by the EPA Team to characterize, manage, and dispose of investigation-derived wastes (IDW) generated during field activities. IDW generated during the project will be handled in accordance with applicable federal, state, and local regulations. The IDW generated during the field activities is expected to include drill cuttings, development and purge water, decontamination water, personal protective equipment (PPE), disposable sampling equipment, and trash. Waste minimization techniques will be employed where possible to reduce the quantity of IDW generated.

1.1 Containerization and Temporary Storage

The EPA soil staging pad will be used to temporarily manage the different types of IDW (solid [bedrock core, drill cuttings, soil cores] and liquid [monitoring well development water, purge water, decontamination water]) generated during the project. When applicable, IDW will be containerized at the moment of generation, transported, and temporarily staged at the soil staging pad. The soil staging pad is a secure location.

1.2 IDW Characterization

The applicable sampling results will be reviewed and, within applicable federal and state regulations and guidance, all waste generated during site investigation activities will be characterized. Based upon this characterization, potential disposal options will be considered and ultimate disposition for all IDW will be proposed.

1.2.1 Solid IDW

Solid IDW will potentially include bedrock core, drill cuttings, and soil cores and will be field-screened using a SAM 940. Solid IDW segregation will occur at the soil staging pad based on field screening results. Solid IDW with field screening results below 50 microR will be segregated from cuttings with field screening results above 50 microR as a precaution until further characterization is conducted.

Waste disposition soil composite samples will be taken to characterize the solid IDW and will be managed based on the analytical results for each waste disposition sample as follows:

- If results from the waste disposition sampling indicate that the soil contains less than 3.5 picoCuries/gram, then the analytical results will be sent to EPA and/or NMED representatives for approval to dispose of the soils on-site.

- If the results indicate that the soil contains greater than 3.5 picoCuries/gram, then the analytical results will be sent to EPA and/or NMED representatives for approval to dispose of the soil off-site as low-level radiation at an approved facility.

1.2.2 Liquid IDW

Liquid IDW generated will potentially include monitoring well development water, purge water from sampling, and decontamination water. Liquid IDW generated during project activities will be placed in appropriately labeled containers and temporarily staged at the soil staging pad.

1.3 PPE, Disposable Sampling Equipment, and Trash

PPE, disposable sampling equipment, and trash will be contained in sealed plastic trash bags, staged at the soil staging pad, and disposed of as non-hazardous solid waste at a municipal landfill.

1.4 Labeling

If containers of IDW are needed, they will be labeled such that the contents, points of generation, and other pertinent information may be easily identified. Identification will include the following information:

- "Analysis Pending"
- Project Name
- Project Description
- Well Number/Boring Number
- Container Number
- Contents (soil, development water, purge water, etc.)
- Date of Generation
- Contact Phone Number and Company Name

Containers of IDW will be cataloged in the field logbook or on the IDW tracking form. The unique identification number for each container will consist of the location and container number. Containers will be numbered consecutively and will include the media type. Information for material requiring off-site disposal based on laboratory analysis will include all pertinent information regarding the drum, including:

- General label information;
- Whether the material is hazardous or non-hazardous;
- Storage location;
- Proposed disposition of the waste;
- Date manifested from the site;
- Manifest number; and
- Final disposition of the drum/roll-off box.

1.5 Identification of Disposal Options

Disposal requirements for IDW will be based on the results of the sample analyses. The EPA Team Chemist will prepare an analytical summary for each waste stream.

1.6 Off-Site Disposal of lDW

Off-site disposal of IDW will be arranged in a manner appropriate to its classification (e.g., characteristically hazardous waste or non-hazardous, contaminated waste). In general, disposal includes the following activities:

- Procurement of transportation and disposal contractor(s).
- Completion of forms, as appropriate for each disposal facility.
- Completion of manifests.
- Transportation and disposal of the wastes.

Approval to accept the IDW will be required from each facility selected to receive IDW and must be obtained prior to shipment of wastes from the site. Should disposal become an issue, alternate disposal and/or contamination reduction will be discussed with the EPA T to determine potential options.

1.6.1 Contractor Procurement

Subsequent to receipt and evaluation of the analytical results by the EPA Team Chemist, contracting arrangements will be performed to facilitate potential off-site disposal of the IDW with the treatment, storage, or disposal facility (TSDF). Additional analysis of IDW may be required by the disposal facility.

1.6.2 Completion of Manifests and Associated Forms

Preparation of manifests and associated forms will be performed by the EPA Team. The EPA representative will be responsible for signing the manifests as the generator of the wastes. Copies of the manifests and associated forms will be sent to the appropriate personnel and maintained in the EPA Team's Project files.

1.6.3 Transportation and Disposal of Wastes

Solid and liquid wastes will be disposed at selected facilities based on the IDW classification. Transportation of IDW from the site to the selected TSDF will be performed by the selected disposal facilities or by appropriately licensed transporters.

APPENDIX E

TDD NO. 19/WESTON-042-15-004

EPA **Technical Direction Document**

U.S. EPA, Region 6
1445 Ross Avenue, Suite 1200
Dallas, TX 75202-2733

Vendor : WESTON SOLUTIONS, INC.

TDD # : 19/WESTON-042-15-004
Amendment # :
Contract # : EP-W-06-042

TDD Title : Tronox Mine (San Mateo Basin)
Purpose : TDD INITIATION
Priority : HIGH
Overtime Authorized : No
Invoice Unit :

Verbal Date :
Start Date : 02/04/2015
Completion Date : 04/01/2015
Effective Date : 02/04/2015

SSID : A6KD
Project/Site Name : Tronox Mine Sites R6/R9
Project Address : Highway 509
County : McKinley
City : Ambrosia Lake
State : NM
Zip Code : 87020

Work Area : Assessment / Inspections Activities
Work Area Code : 91
Activity : Integrated Assessment (IA) (Pipeline Only)
Activity Code : EA
Operable Unit :
Emergency Code :
FPN :
Performance Based : No

Authorized TDD Ceiling :

	Amount	[redacted]
Previous Action(s) :	$0.00	[redacted]
This Action :	[redacted]	[redacted]
New Total :	[redacted]	0.00

Specific Elements :
Prepare -Work Plan for San Mateo Basin Groundwater Investigation (Tronox Mines)

Description of Work :
See Schedule

Region Specific :
CERCLIS:
Misc 2 :

Accounting and Appropriation Information: **SFO:**

Line	Budget / FY	Approp. Code	Budget Org.	Program Element	Object Class	Site Project	Cost Org.	DCN Line-ID	Funding Category	TDD Amount
1	13	T	6A00	303DD2	2505	A6KDRS00	C001	146APLC038-001	CERCLA PIPELINE	[redacted]
2	10	T	9AK0	302DD2C	2505	A6KDRS00	C059	109AK0P010-001	REGIONAL FUNDS	[redacted]

U.S. EPA, Region 6
1445 Ross Avenue, Suite 1200
Dallas, TX 75202-2733

Vendor : WESTON SOLUTIONS, INC.

TDD # : 19/WESTON-042-15-004
Amendment # :
Contract # : EP-W-06-042

Project Officer : Will LaBombard (Signature) (Date)	**Branch Mail Code:** **Phone Number :** 214-665-7199 **Fax Number :**
Contracting Officer Representative : Brenda Cook (Signature) (Date)	**Branch Mail Code :** **Phone Number :** 214-665-7436 **Fax Number :**
Contract Specialist: Michael J. Pheeny (Signature) (Date)	**Branch Mail Code :** **Phone Number :** 214-665-2798 **Fax Number :**
Contracting Officer : Michael J. Pheeny Electronically Signed by Michael J. Pheeny 02/04/2015 (Signature) (Date)	**Branch Mail Code :** **Phone Number :** 214-665-2798 **Fax Number :**
Other Agency Official : (Signature) (Date)	**Branch Mail Code :** **Phone Number :** **Fax Number :**

Description of Work:Initial funding is set at(b) (4) [redacted].

This TDD is being iniated to begin workplan development of the Phase II San Mateo Uranium Basin Ground Water Investigation-Tronox Mines for FY2015. This TDD will cover initial costs to prepare work plan for Phase II until a separate task order/funding mechanism is in place. Once a separate funding mechanism is place- this TDD will be completed with an AOC of detailing activites in support of workplan development and the final workplan will be submitted under the new task order.

The scope of Work Plan, Other Plans and Cost Estimates- Prepare a site-specific work plan, quality assurance sampling plan (QASP), health and safety plan (HASP) and investigation-derived waste plan (IDWP). As part of work plan preparation, develop data quality objectives (DQOs) in accordance with EPA guidance. Develop individual cost estimates for completing the Phase II Groundwater Investigation collection at the San Mateo Creek Basin Legacy Uranium Sites and include them with the work plan. A draft project schedule shall also be developed and included with the draft work plan.

Key Components for the FY2015 Proposed Activities in 2015:
¿ Sampling of alluvial groundwater wells installed in 2014 in Spring and Fall in order to catch snow melt and post-monsoon groundwater conditions
¿ Installation of additional alluvial groundwater wells (10) to further attribution to certain mines and mine activities and sampling in Spring and Fall in order to catch snow melt and post-monsoon groundwater conditions
¿ Installation of bedrock wells into the Dakota Sandstone (8) in the Ambrosia Lake area where the sandstone subcrops in the alluvium, together with one round of sampling upon completion of well development
¿ Field investigation, data interpretation, and development and evaluation of actions to address unacceptable risk at Section 35 and 36 (Cliffside) Mine Sites

Primary contact is Lisa Price Grants Mining District Coordinator.

EPA

Technical Direction Document

U.S. EPA, Region 6 1445 Ross Avenue, Suite 1200 Dallas, TX 75202-2733 Vendor : WESTON SOLUTIONS, INC.	TDD # : 19/WESTON-042-15-004 Amendment # : 001 Contract # : EP-W-06-042

TDD Title : Tronox Mine (San Mateo Basin)	Verbal Date :
Purpose : EXTEND POP,ADD CO-WAMS	Start Date : 02/04/2015
	Completion Date : 06/01/2015
	Effective Date : 02/04/2015
Priority : HIGH	
Overtime Authorized : No	
Invoice Unit :	

SSID : A6KD	Work Area : Assessment / Inspections Activities
Project/Site Name : Tronox Mine Sites R6/R9	Work Area Code : 91
Project Address : Highway 509	Activity : Integrated Assessment (IA) (Pipeline Only)
County : McKinley	Activity Code : EA
City : Ambrosia Lake	Operable Unit :
State : NM	Emergency Code :
Zip Code : 87020	FPN :
	Performance Based : No

Authorized TDD Ceiling :

	Amount	LOE (Hours)
Previous Action(s) :	[redacted]	0.00
This Action :	$0.00	0.00
New Total :	[redacted]	0.00

Specific Elements :

See Schedule

Description of Work :

See Schedule

Region Specific :

CERCLIS:

Misc 2 :

Accounting and Appropriation Information: **SFO:**

Line	Budget / FY	Approp. Code	Budget Org.	Program Element	Object Class	Site Project	Cost Org.	DCN Line-ID	Funding Category	TDD Amount

U.S. EPA, Region 6
1445 Ross Avenue, Suite 1200
Dallas, TX 75202-2733

Vendor : WESTON SOLUTIONS, INC.

TDD # : 19/WESTON-042-15-004
Amendment # : 001
Contract # : EP-W-06-042

Project Officer : Will LaBombard (Signature) (Date)	**Branch Mail Code:** **Phone Number :** 214-665-7199 **Fax Number :**
Contracting Officer Representative : Brenda Cook (Signature) (Date)	**Branch Mail Code :** **Phone Number :** 214-665-7436 **Fax Number :**
Contract Specialist: Michael J. Pheeny (Signature) (Date)	**Branch Mail Code :** **Phone Number :** 214-665-2798 **Fax Number :**
Contracting Officer : Michael J. Pheeny Electronically Signed by Michael J. Pheeny 03/31/2015 (Signature) (Date)	**Branch Mail Code :** **Phone Number :** 214-665-2798 **Fax Number :**
Other Agency Official : (Signature) (Date)	**Branch Mail Code :** **Phone Number :** **Fax Number :**

Specific Elements:
Base ORIG - Prepare -Work Plan for San Mateo Basin Groundwater Investigation (Tronox Mines)
Description of Work:
Amendment 001 - This amendment adds Lisa Price as an additional COR on the TDD and extends the POP to 06/01/2015 to allow for continued work.

Base ORIG - Initial funding is set at (b) (4) [redacted].

This TDD is being iniated to begin workplan development of the Phase II San Mateo Uranium Basin Ground Water Investigation-Tronox Mines for FY2015. This TDD will cover initial costs to prepare work plan for Phase II until a separate task order/funding mechanism is in place. Once a separate funding mechanism is place- this TDD will be completed with an AOC of detailing activites in support of workplan development and the final workplan will be submitted under the new task order.

The scope of Work Plan, Other Plans and Cost Estimates- Prepare a site-specific work plan, quality assurance sampling plan (QASP), health and safety plan (HASP) and investigation-derived waste plan (IDWP). As part of work plan preparation, develop data quality objectives (DQOs) in accordance with EPA guidance. Develop individual cost estimates for completing the Phase II Groundwater Investigation collection at the San Mateo Creek Basin Legacy Uranium Sites and include them with the work plan. A draft project schedule shall also be developed and included with the draft work plan.

Key Components for the FY2015 Proposed Activities in 2015:
¿ Sampling of alluvial groundwater wells installed in 2014 in Spring and Fall in order to catch snow melt and post-monsoon groundwater conditions
¿ Installation of additional alluvial groundwater wells (10) to further attribution to certain mines and mine activities and sampling in Spring and Fall in order to catch snow melt and post-monsoon groundwater conditions
¿ Installation of bedrock wells into the Dakota Sandstone (8) in the Ambrosia Lake area where the sandstone subcrops in the alluvium, together with one round of sampling upon completion of well development
¿ Field investigation, data interpretation, and development and evaluation of actions to address unacceptable risk at Section 35 and 36 (Cliffside) Mine Sites

Primary contact is Lisa Price Grants Mining District Coordinator.

EPA **Technical Direction Document**

U.S. EPA, Region 6
1445 Ross Avenue, Suite 1200
Dallas, TX 75202-2733

Vendor : WESTON SOLUTIONS, INC.

TDD # : 19/WESTON-042-15-004
Amendment # : 002
Contract # : EP-W-06-042

TDD Title : Tronox Mine (San Mateo Basin)
Purpose : INCREMENTAL FUNDING
Priority : HIGH
Overtime Authorized : No
Invoice Unit :

Verbal Date :
Start Date : 02/04/2015
Completion Date : 06/01/2015
Effective Date : 02/04/2015

SSID : A6KD
Project/Site Name : Tronox Mine Sites R6/R9
Project Address : Highway 509
County : McKinley
City : Ambrosia Lake
State : NM
Zip Code : 87020

Work Area : Assessment / Inspections Activities
Work Area Code : 91
Activity : Integrated Assessment (IA) (Pipeline Only)
Activity Code : EA
Operable Unit :
Emergency Code :
FPN :
Performance Based : No

Authorized TDD Ceiling :

	Amount	LOE (Hours)
Previous Action(s) :	(b) (4) [redacted]	0.00
This Action :	$0.00	0.00
New Total :	(b) (4) [redacted]	0.00

Specific Elements :
See Schedule

Description of Work :
See Schedule

Region Specific :
CERCLIS:
Misc 2 :

Accounting and Appropriation Information: **SFO:**

Line	Budget / FY	Approp. Code	Budget Org.	Program Element	Object Class	Site Project	Cost Org.	DCN Line-ID	Funding Category	TDD Amount
1	13	T	6A00	303DD2	2505	A6KDRS00	C001	146APLC038-001	CERCLA PIPELINE	(b) (4) [redacted]
2	10	T	9AK0	302DD2C	2505	A6KDRS00	C059	109AK0P010-001	REGIONAL FUNDS	(b) (4) [redacted]

U.S. EPA, Region 6
1445 Ross Avenue, Suite 1200
Dallas, TX 75202-2733

TDD # : 19/WESTON-042-15-004
Amendment # : 002
Contract # : EP-W-06-042

Vendor : WESTON SOLUTIONS, INC.

Project Officer : Will LaBombard	**Branch Mail Code:**
(Signature) (Date)	**Phone Number :** 214-665-7199
	Fax Number :
Contracting Officer Representative : Brenda Cook	**Branch Mail Code :**
(Signature) (Date)	**Phone Number :** 214-665-7436
	Fax Number :
Contract Specialist: Michael J. Pheeny	**Branch Mail Code :**
(Signature) (Date)	**Phone Number :** 214-665-2798
	Fax Number :
Contracting Officer : Michael J. Pheeny	**Branch Mail Code :**
Electronically Signed by Michael J. Pheeny (Signature) 04/23/2015 (Date)	**Phone Number :** 214-665-2798
	Fax Number :
Other Agency Official :	**Branch Mail Code :**
(Signature) (Date)	**Phone Number :**
	Fax Number :

Specific Elements:
Base ORIG - Prepare -Work Plan for San Mateo Basin Groundwater Investigation (Tronox Mines)
Description of Work:
Amendment 002 - Incremental funding of [redacted] to continue preparation of the San Mateo Basin Groundwater Investigation Work Plan.
Amendment 001 - This amendment adds Lisa Price as an additional COR on the TDD and extends the POP to 06/01/2015 to allow for continued work.

Base ORIG - Initial funding is set at [redacted].

This TDD is being iniated to begin workplan development of the Phase II San Mateo Uranium Basin Ground Water Investigation-Tronox Mines for FY2015. This TDD will cover initial costs to prepare work plan for Phase II until a separate task order/funding mechanism is in place. Once a separate funding mechanism is place- this TDD will be completed with an AOC of detailing activites in support of workplan development and the final workplan will be submitted under the new task order.

The scope of Work Plan, Other Plans and Cost Estimates- Prepare a site-specific work plan, quality assurance sampling plan (QASP), health and safety plan (HASP) and investigation-derived waste plan (IDWP). As part of work plan preparation, develop data quality objectives (DQOs) in accordance with EPA guidance. Develop individual cost estimates for completing the Phase II Groundwater Investigation collection at the San Mateo Creek Basin Legacy Uranium Sites and include them with the work plan. A draft project schedule shall also be developed and included with the draft work plan.

Key Components for the FY2015 Proposed Activities in 2015:
¿ Sampling of alluvial groundwater wells installed in 2014 in Spring and Fall in order to catch snow melt and post-monsoon groundwater conditions
¿ Installation of additional alluvial groundwater wells (10) to further attribution to certain mines and mine activities and sampling in Spring and Fall in order to catch snow melt and post-monsoon groundwater conditions
¿ Installation of bedrock wells into the Dakota Sandstone (8) in the Ambrosia Lake area where the sandstone subcrops in the alluvium, together with one round of sampling upon completion of well development
¿ Field investigation, data interpretation, and development and evaluation of actions to address unacceptable risk at Section 35 and 36 (Cliffside) Mine Sites

Primary contact is Lisa Price Grants Mining District Coordinator.

APPENDIX C

TASK ORDER COST ESTIMATE

(b) (4)

[redacted]

(b) (4)

[redacted]

Laboratory Detail Estimate

Parameter	Quantity	Unit Cost	Extended Cost
TAL Metals + Uranium (total) by SW 6020	55	(b) (4) [redacted]	(b) (4) [redacted]
Mercury (total) by SW 7470	55	[redacted]	[redacted]
TAL Metals + Uranium (dissolved) by SW6020	55	[redacted]	[redacted]
Mercury (dissolved) by SW 7470	55	[redacted]	[redacted]
Anions by 300.0 / 9056	55	[redacted]	[redacted]
pH by 150.1 / 9040B / 9045C	55	[redacted]	[redacted]
Total Dissolved Solids (TDS) by 160.1 / SM2540C	55	[redacted]	[redacted]
Alkalinity by 310.1m / SM2320Bm	55	[redacted]	[redacted]
Isotopic Uranium (Alpha Spectrometry) U-233/234, U235/236, U-238 by ASTM D3972-90M	55	[redacted]	[redacted]
Isotopic Thorium (Alpha Spectrometry): Th-228, Th-230, Th-232, Th-227 by ASTM D3972-90M	55	[redacted]	[redacted]
Gross Alpha/Beta by EPA 900.0 / 9310	55	[redacted]	[redacted]
Radium 226 by EPA 903 / 9315	55	[redacted]	[redacted]
Radium 228 by EPA 904 / 9320	55	[redacted]	[redacted]
Stable Isotopes (total of 4)	55	[redacted]	[redacted]
SPLP Tumble by SW1312	25	[redacted]	[redacted]
SPLP – Radium 226 by EPA 903.0 / 9315	25	[redacted]	[redacted]
SPLP – Radium 228 by EPA 904.0 / 9320	25	[redacted]	[redacted]
SPLP – TAL Metals + Uranium by SW6020	25	[redacted]	[redacted]
SPLP – Mercury by SW7470	25	[redacted]	[redacted]
SPLP – Isotopic Thorium (Th-228, Th-230, Th-232, Th-227) by ASTM 3972-90M	25	[redacted]	[redacted]
SPLP – Isotopic Uranium (U-233/234, U235/236, U-238) by ASTM D3972-90M	25	[redacted]	[redacted]

(b) (4) [redacted]

The estimated quantity of water samples collected (55) includes duplicate samples at 1 per 10 collected, equipment rinsate blanks collected 1 per week of drilling/sampling and MS/MSD collected 1 per 20 samples.

Drilling Detail Estimate

Item	Description	Unit	Quantity	Unit Cost	Total
	Alluvial Wells (14 proposed)				
1	Mobilization/Demobilization	Lump Sum	1	(b) (4) [redacted]	(b) (4) [redacted]
2	Drill and continuously sample 14 soil borings to a depth between 30 feet and 120 feet below ground surface.	Foot	1680	[redacted]	[redacted]
3	Install 14, 2-inch schedule 40 PVC alluvial monitoring wells using appropriate number of centralizers, sand pack, bentonite pellets, grout to surface and complete wells with 4 feet by 4 feet concrete pad and protective locking steel casing.	Foot	1680	[redacted]	[redacted]
4	Plugging and abandonment of 14 soil borings not converted to monitoring wells according to State of New Mexico regulations.	Foot	0	[redacted]	[redacted]
	Dakota Sandstone Wells (7 proposed)			[redacted]	[redacted]
5	Mobilization/Demobilization for Dakota Sandstone (if necessary)	Lump Sum	0	[redacted]	[redacted]
6	Install 10-inch surface casing to a depth ranging from 30 feet to 120 feet below ground surface.	Foot	840	[redacted]	[redacted]
7	Drilling and continuously sample 7 to a depth between 120 feet and 300 feet. below ground surface	Foot	1260	[redacted]	[redacted]
8	Install 7, 4-inch schedule 80 PVC alluvial monitoring wells using appropriate number of centralizers, sand pack, bentonite pellets, grout to surface and complete wells with 4 feet by 4 feet concrete pad and protective locking steel casing.	Foot	2100	[redacted]	[redacted]
	San Andres Well (1 proposed)			[redacted]	[redacted]
9	Mobilization/Demobilization for San Andres (if necessary)	Lump Sum	1	[redacted]	[redacted]
10	Install 16-inch surface casing to a depth ranging from 30 feet to 120 feet below ground surface.	Foot	120	[redacted]	[redacted]
11	Install 10-inch surface casing to a depth of approximately 600 feet bgs.	Foot	480	[redacted]	[redacted]
12	Drilling and continuously sample to a depth a depth of approximately 700 ft. below ground surface	Foot	100	[redacted]	[redacted]
13	Install one 5-inch schedule 80 PVC alluvial monitoring wells using appropriate number of centralizers, sand pack, bentonite pellets, grout to surface and complete wells with 4 feet by 4 feet concrete pad and protective locking steel casing.	Foot	700	[redacted]	[redacted]
	General Costs			[redacted]	[redacted]
14	Plugging and abandonment of soil borings not converted to monitoring wells according to State of New Mexico regulations.	Foot	0	[redacted]	[redacted]
15	Containerizing soil cuttings from each boring and/or monitoring well locations and transport to the soil staging area for drop off.	EA	22	included	[redacted]
16	Standby Time	Hour	8	(b) (4) [redacted]	[redacted]

Drilling Cost (b) (4) [redacted]
(b) (4) [redacted]

Geophysics Detail Estimate

	Description	Unit Cost ($)	Estimated Quantity (n)	Units	Total Time (days)	Total Cost ($)	Comment
1.0	**Mobilization/Demobilization (including per diem, if any)**	(b) (4) [redacted]	**1**		**2**	(b) (4) [redacted]	
2.0	**Perform geophysical logging of one (1) existing 5 inch PVC cased irragation well to an estimated depth between 600 ft and 700 ft below ground surface (bgs) including additional time/footage for Quality Assurance Repeat Run per the SOW.**	[redacted]	**700**	**$/ft**		[redacted]	
3.0	**Perform geophysical logging of seven (7) newly installed 4-in PVC cased monitoring wells to an estimated depth of 150 ft bgs.**	[redacted]	**1050**	**$/ft**		[redacted]	
4.0	**Perform geophysical logging of one (1) newly installed 5-in PVC cased monitoring well to an estimated depth between 600 and 700 ft bgs.**	[redacted]	**700**	**$/ft**		[redacted]	
5.0	**Cost for additional logging of 5 inch PVC irragation well beyond 700 ft to 900 ft bgs.**	[redacted]	**200**	**$/ft**		[redacted]	
6.0	**Reporting/Deliverables of final logs.**	[redacted]	**2**			[redacted]	

Well geophysics cost (b) (4) [redacted]

(b) (4) [redacted]